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Detection and Tracking Survey for Smart Home Using Wireless Sensor Network

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Abstract: Wireless Sensor Networks (WSNs) provide promising solutions for monitoring in several domains including industrial monitoring and control; home automation and smart cities, security and military sensing, traffic management, asset tracking and supply chain management, intelligent agriculture and environmental sensing and health monitoring. WSNs support features of continuous and event-driven monitoring, thus, they have been utilized for smart cities where gathering information for public safety purposes can be of great benefits. Also, indoor environmental monitoring takes the leads of WSNs applications which concerns abnormal event detection and target tracking where the network can provide light, temperature and activity measurements. For instance, WSNs have been used to sense indoor environmental pollution and monitor temperature, gas leakage, fire spread as well as intruders.

Key words: Wireless Sensor Network (WSN), smart home, object detection, moving objects tracking, envirnomental pollution, traffic managment

INTRODUCTION

The recent years have witnessed a hug attention being given towards WSNs has been resulted in developing beneficial and practical systems, passing the pure theoretical research stages. This is due to the continuous demand on this type of networks where sensors are used for performing particular monitoring tasks. However, there are several challenges when it comes to satisfying the requirements of the applications whiling ensuring smooth operation of the network. Undeniably, based on the tasks for which WSNs are designed, specific architectures, protocols and mechanisms should be employed (Akyildiz *et al*., 2007; Yu *et al*., 2006). Thus, according to Lan *et al*. (2008), architectures and protocols are the main elements of designing WSNs.

Since, a WSN is composed of and deployed in a big number of sensing nodes for monitoring an area of interest, effective and reliable protocols and algorithms are required for efficient management of the network functions such as medium access control, self-configuration, transmission synchronization, localization, data aggregation, routing and security. Nevertheless, the resources limitations of power, computation capacity and storage capacity, holds back the use of several mechanisms designed for traditional wireless networks, namely Mobile Ad-hoc Networks MANETs and cellular systems where restrictions were not taken into account (Carrera and Perez, 2014). As WSNs are considered as application-specific networks where the specifications and requirements differ accordingly, new protocols, algorithms and mechanisms should be developed where such resource limitations must be considered. This study presented the background on Wireless Sensor Networks (WSNs). Moreover, surveillance and monitoring using WSNs besides object detection and tracking were described afterwards where the related research works are compared for high lighting their advantages and the associated problems.

Surveillance and object monitoring using WSNs: As sensors are capable of accurately sensing temperature, light, air pollution and moving objects, WSN's technology become the promising solutions for in smart and efficient monitoring (Gungor *et al*., 2010; El-Bendary *et al*., 2013; Robol *et al*., 2015; Prabhu *et al*., 2016). With the use of WSNs, smart, safer and secure environment for residents can be ensured. For instant, WSNs can be of great benefits to save lives where they can be smartly used to timely detect intruder and other

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events interior atmospheric such gas leak, explosions, smoke, fire and many more that would have catastrophic consequences (Prabhu *et al*., 2016).

Since, the occurrence of such events is naturally random and unexpected it would enforce serious challenges on the network smart home system in regards to dependency and data diversity (Xiao *et al*., 2016). Normally, when an event such as intrusion occur, it presents itself arbitrarily and there might be noticeable physical evidence is witnessed of their occurrence when completed or they pass without notice based on the purpose of the intruder. Such target may occur for short time period where the consideration must be on maximizing the detection probability wherever the target moves or for long time where minimizing the detection delay must be prioritized. In the following, the related research works on target detection and tracking are reviewed together with techniques, algorithms and analysis applicable for WSNs that are used to detect and track an intrusion event.

Object detection and notification: In WSNs applications that are developed for monitoring a dynamically moving target, efficacious detection is subject to two important metrics (Zhu and Ni, 2016): detection probability: it is related to the chance of that a moving object is detected in the sensing field. Detection delay: it is related to the time needed for the detection information to arrive at the base station or the sink. Many approaches have been proposed for target detection considering the aforementioned metrics. Here, we present the well-known target detection and notification techniques together with related existing work.

Distributed cooperative target detection: A better energy efficiency and high accuracy of target detection can be realized by a distributed sensing evaluation compared to centralized ones (Wittenburg *et al*., 2012). In multi-hop WSNs, the cost of propagating the reports of the event detection from the detecting nodes to the sink can be significant. Collaboration of neighboring nodes on deciding whether or not there is sufficient evidence exists to trigger the propagation of target detection notification would be of benefits regarding energy saving and accurate detection of the target as well as the detection delay (Wu *et al*., 2016). Accordingly, a classifier based distributed detection system was proposed by Dziengel *et al*. (2016). They stated that if parts of events are cooperatively composed by nodes, a comprehensive assessment of an event with low energy consumption is possible. The experimental evaluation results of their proposed system with WSN of 49 nodes integrated in construction site fence elements, showed that the energy consumption is reduced beyond a two-hop distance communication while achieving high event detection accuracy. Based on probabilistic significance of the observations, sensing nodes can be collaboratively designated for monitoring an event and the network topology can then be adjusted to enhance energy efficiency where the CH is responsible of forwarding the sensed data. This concept has been utilized in the Probabilistic Event Monitoring Scheme (PEMS) proposed by Das and Misra (2015). Cooperative distributed detection framework was proposed by Nasridinov *et al*. (2014) where Negative Pressure Wave (NPW) is integrated with intelligent machine learning techniques to define specific events based on raw sensed data. Support Vector Machine (SVM), k-Nearest Neighbor (kNN) and Gaussian Mixture Model (GMM) were applied in multi-dimensional feature space. The proposed system was validated on a field deployed test-bed aiming at detecting the leakages in pipelines.

It is concluded that although, more accurate and comprehensive understanding of when and where the events have happened can be achieved by distributed cooperative target detection it does not contribute to false-positive detection of the outcome. Nevertheless, exchanging collaboration information can delay the delivery of detection notifications.

Active/Inactive mode scheduling: Periodic sleep scheduling is suitable method for event-driven WSNs where event detection is assured with satisfactory life span of the network operation. The periodic sleep scheduling is highly preferred when it comes to energy optimization and reducing the overall energy consumption (Rajesh and Reddy, 2016). To improve the operational life of a WSN, sensor nodes are scheduled to put down their power. Always active method (discuss later in this subsection) does not satisfy the longevity requirements in some event detection scenarios. In this context, Misra *et al*. (2015) had proposed Probabilistic Duty Cycle in Sensor Medium Access Control (PDC-SMAC) protocol to minimize the ineffective sensing (where node is active but there is nothing to detect) that would in turn prolong the network life time. The performance evaluation results demonstrated that PDC-SMAC minimizes report delivery latency by 27-60% for different intervals of packet generation and by 47% for different rates of event occurrence. Also, to limit the reporting delay (Kavitha and Lalitha, 2014) introduced on-demand level-by-level sleep scheduling method where the schedule to sleep mode is done dynamically based on the reports arrival time. Controlling, the time when the node should be active is done based on probabilistic models that are incorporated with target prediction; hence, ensuring high detection probability. The simulation results of the performance evaluation proved that the proposed method achieves its goals while guarantees long lived operation.

It is clear that for situations where an intruder inside premise is detected, detection delay is very critical as disseminating detection notification through large multi-hop network can be drastically affected by intermediate nodes that use sub-optimal sleep scheduling. The detection probability with the use of this technique is reduced; however, increasing the number of nodes detecting the event can lessen the negative effect on detection probability but at the cost of more network overhead due to control messages exchanged for synchronization.

Activating/deactivating node transceiver: Another option to full active-inactive mode scheduling is powering down the wireless transceiver which the most component consuming the node energy. Beside that energy is unavoidably used for data transmission and receiving, energy is significantly wasted through media collisions and related retries in addition to the idle listening where the transceiver is energized but receives no packets. Thus, deactivation of the transceiver when there is nothing to listen or receive can be of benefits in most of WSNs including Implantable Body Sensor Networks (IBSN) (Ramachandran *et al*., 2016). From this angle, aiming at reducing idle listening and hence enhancing energy efficiency (Karvonen *et al*., 2014) had proposed a Generic Wake-up Radio based Medium Access Control (GWR-MAC) protocol for short range communication WSNs. GWR-MAC includes source-initiated and sink-initiated wake-up procedures. As a function of number of events to enable the proper selection of a radio with respect to the application scenarios, the analytical comparison to the conventional periodic sleep scheduling MAC methods GWRMAC would be useful for detecting events that require a reasonable low detection delay. Deactivation of transceiver power is also used by Yoo *et al*. (2012) and in some other protocols such as DW-MAC by Sun *et al*. (2008) where sleeping transceivers are awakened on demand while assuring that data transmissions will not be collided at receiving intermediate nodes and TRAMA by Rajendran *et al*. (2006) where collision free transmission is guaranteed and transceivers are power down when nodes are not required to transmitting or receive reports.

It is important to mention that powering on the transceiver frequently requires energy same as transmission of one data packet which increases the total energy consumption (Olds and Seah, 2012). With such technique, the detection probability is not affected as the main sensing components are not powered off. However, deactivating the transceiver leads to unavoidable delay of transmitting the reports to the interested sink node. Also, powering up the transceiver contributes to the overall energy consumption of the network.

Number of sensing active node: It is clear that the longevity of a WSN is increased with the use of periodic sleep scheduling method (discussed earlier); however, the sensing coverage is reduced and hence affecting the detection probability. Sufficient density of nodes helps in maintaining the sensing coverage in the monitoring area as it allows a proper synchronization of sleep scheduling among the nodes in the network. Adding redundant nodes within the coverage of adjacent sensing node pairs allows maintaining optimal coverage and can offer faults tolerance environment. Harrison *et al*. (2015) had proposed an Equitable Sleep Coverage Algorithm for Rare Geospatial Occurrences (ESCARGO) which assures well-timed delivery of event reports while maintaining network connectivity constantly. It was shown that adding redundant nodes to a WSN with low node density and non-random deployment strategy, ESCARGO can extend the network lifetime without compromising detection probability or detection delay. Redundant nodes were used by Sheth *et al*. (2005) in their proposed landslide prediction system (SENSLIDE) which a distributed sensor system that includes event detection and data capturing. The system was designed to robustly deal with the complexities of a distributed WSN environment where connectivity is poor and power is very limited. Premature depletion of node's energy was prevented by utilizing energy-aware routing protocols. The use of the redundant nodes had enabled SENSLIDE to achieve satisfactory level of fault tolerance. It is obvious that periodic sleep scheduling algorithms can maintain coverage, if redundant nodes are deployed in the monitoring area. Hsin and Liu (2004) had concluded that the dynamic topology change resulting from sleep scheduling has negative effect on the network operation and performance which can be compensated by adding redundancy in the node deployment. Within the context of providing network coverage to provide high detection probability they studied two types sleep modes, random sleep and coordinated sleep to show the benefits of redundant nodes. It was shown that at the expense of extra control overhead, a coordinated sleep schedule is more robust compared to a random sleep schedule with the same amount of node redundancy. Node density has been considered in several research works such as Mohamed *et al*. (2014) and Zhu *et al*. (2012).

It is known that as timely detection of transient events requires a perfect detection probability, target detection probability can be increased by increasing node density. But, it adds an additional complexity to the network which may result in delaying the dissemination of the event notifications.

Filtering notification reports: When an event is detected by several neighboring nodes they generate a lot of similar notification reports. That is these reports are considered duplicates and thus, forwarding a part of them may be enough to confirm on occurrence of the event. In this context in this context (Harrison *et al*., 2016) proposed Swift Opportunistic Forwarding of Infrequent Events (SOFIE) to ensure event detection and quick propagation of event notification reports. It provides perfect area coverage based on the geometric properties that are common to WSN. It was shown that with SOFIE, event notification reports are delivered rapidly compared to the traditional geographic forwarding algorithm in optimally and randomly deployed networks with different node densities. Besides, it was shown that SOFIE maintains the sensing coverage in a WSN with periodic sleep scheduling where mainly sensing nodes can sleep during the propagation of event notification reports by other active nodes. Also, Yang *et al*. (2012) had proposed a novel algorithm to achieve rapid reaction to real time event detection in WSN. The proposed algorithm was designed based on clustering, hence, only one representative node needs to report its data. Therefore, less number of nodes is involved in the data communication which can guarantee less delay in the propagation of the event notification reports. In addition, energy efficiency can be achieved in terms of transmission. To minimize needless communication between nodes and to offer early event detection, (Pripuzic *et al*., 2008) had proposed new technique for suppressing the overwhelming propagation of the notification reports using sliding window skylines. The proposed technique was experimentally evaluated to prove its usability for environmental applications such as forest fire detection.

It was observer that filtering of notifications has no impact on the detection probability as it concerns the transmission and propagation of the notifications within the network. The event notification reports can be delivered to the network sink or base station more quickly if the duplicated reports are removed or suppressed; hence, controlling the amount of the unnecessary traffic load in the network which in turn, reduces the detection delay significantly.

Constantly active node: Some event monitoring applications (such as temperature and gas leak and structural vibrations monitoring) where the consequences of missing an event occurrence would have serious undesirable effects, require that sensor nodes should be always active and that notification reports must be delivered as fast as possible. Even though that the longevity of always on WSNs is an issue especially in a large detection system, considering an always-active method, however, remains a proper procedure in certain situations (Han *et al*., 2014). Yet, utilizing other methods and strategies such as reports filtering and aggregation in always-active WSN environment, nodes are constantly busy sensing the environment (Xu *et al*., 2012). In this context, Antolin *et al*. (2017) considered wearable wireless sensor network for indoor smart environment monitoring and proposed a low power Low-Rate Wireless Personal Area Network (LR-WPAN) communications protocol for monitoring CO_2 concentration, temperature and humidity. It is a complete and multipurpose remote web application with a locally executed decision-making system which enables early detection of dangerous situations for indoor exposed residents and workers. The microcontroller in the system can be set to a low-power mode and thus reducing the energy consumption while nodes are kept always active to minimize their response time. The system also allows periodic sleep scheduling and transceiver deactivation according to the operation frequencies. Likewise, Srbinovska *et al*. (2015) had proposed a WSN architecture for vegetable greenhouse aiming at achieving scientific cultivation and lower management costs from the aspect of environmental monitoring. A practical and low-cost greenhouse monitoring system was designed based on the analysis of the greenhouse environment features and it is capable of monitoring the main environmental parameters such as temperature, humidity and illumination. In the same domain, Viani *et al*. (2012) had proposed indoor monitoring system for museum environment to conserve artworks or detect events to prevent unauthorized access and vandalis especially during temporary exhibits. Nodes in the proposed system are always active to maximize the detection probability. Usually, in such indoor environment, power is provided sufficiently, hence, prolonging the network operation is not of concern.

It is clear that constantly active node technique can increase the detection probability significantly and may decrease the detection delay as there is no overhead of active/sleep modes transition and the associated communication. Nonetheless, energy consumption will be an issue, especially in the environment where recharging or replacing batteries is impossible.

RESULTS AND DISCUSSION

Tracking of moving object: In addition to environmental monitoring and target detection, tracking of a target is of the most important applications of WSNs (for instance, tracking of wildlife, human, object, etc.,) where sensing nodes notify about the locations of the target with a minimum latency. Target tracking can be done whether by using a single node which however, introduces unreliability to the monitoring system due to node failure as a result of high computation overhead, depleting entire energy or damaged by the target or by using several nodes that cooperate to track the target which can provide high accuracy and energy efficiency and overcome aforementioned node failure issues. Depending on the application specification and requirements, tracking a target can be done in several ways. For instance, mobile sink is used to move around the monitoring area to collect data for an efficient tracking (Mili *et al.*, 2010; Hoffmann *et al.*, 2013). While in some other scenarios such as monitoring and controlling the temperature, humidity, sound or light inside a building it is not necessary to deploy mobile nodes or a mobile sink. In the course of improving the safety quality there are some initial significant requirements concerning locating and determining the course of the target. For example, it is very necessary to have an efficient tracking system for emergency services response team working in threatening environments to avoid being halted in danger during their involvements and in providing an appropriate course of action (Khelifi *et al.*, 2017).

There are a lot of research works available in the literature focusing on event tracking, considering the event as a target of a moving object. Such works have been reviewed thoroughly by Darman and Ithnin (2014), Dhore and Patil (2016), Souza *et al.* (2016), Joshi and Deshpande (2017). With respect to the categorization and taxonomy of sensor networks applications presented in target racking systems can be reviewed from several perspectives and according to various metrics such as energy efficiency, accuracy, target mobility and fault tolerance considering the structure network and how the notifications are delivered to the interested entity. The most important performance parameter of WSN's tracking applications is the tracking accuracy. In the design of object monitoring and tracking it is important to consider improving tracking accuracy and reducing the detection delay (where tracking information about identified object must be sent to interested sink as soon as possible) to satisfy the quality of service requirements of the tracking application. In this context, the common systems of event tracking are reviewed in this section according to network structure, prediction-based systems, target type, sensor type, number of the targets and recovery approaches which are the common elements that can be considered in object tracking.

By Darabkh *et al.* (2012) had proposed three mechanisms, namely adaptive head, static head and selective static head for target tracking based on clustering. With these systems, promising tracking accuracy and energy efficiency were achieved by choosing nodes close to the targeted event to become involved in the tracking process, yet other nodes are preserved in sleep state. In each of the proposed three mechanisms, the behavior of the nodes in the tracking process is described by a state transition model. Furthermore, a recovery phase was included in case the target is lost during the tracking process. For instance, in the adaptive head mechanism an alarm is sent by the master node to all nodes in the network. When, the target is detected by a node that node would reply and enters the master election phase. However, in the static and selective static heads mechanisms, the alarm is forwarded between CHs until capturing the target. Nevertheless with the adaptive head mechanism as the speed of the target increases tracking errors rate increases as well. This is because of error accumulations created when approximating the location of the target in addition to the added measurements of Time of Arrival (TOA) (which is classic methods to estimate the indoor target location by measuring travel times of signals between nodes (Cheng *et al.*, 2012).

On the other hand, boundary problem is one of the problems associated with static clustering. This problem is initiated when nodes in different clusters incapable of exchanging information among them, leading to a boundary problem when the event evolves (i.e., target moves) along the clusters boundaries. To tackle this problem (Wang *et al.*, 2013) had developed a Hybrid Cluster-based Target Tracking (HCTT) which can provide efficient tracking integrating on-demand dynamic clustering features into a cluster-based WSN. Once nodes are deployed they are organized into static clusters and cooperate with each other within the cluster to track the target. In order the overcome the boundary problem, a dynamic cluster is formed at boundary regions by the on-demand dynamic clustering process when the moving target approaches the cluster boundaries, allowing sharing information temporarily between nodes detecting the target from different static clusters. The dynamic cluster is then terminated once the target moves away from the cluster boundaries. However, in regards to creating, maintaining and terminating dynamic clusters, the on-demand dynamic clustering technique used introduces high overhead. Energy consumption for the said operations would result in an early death of nodes which in turn, affects the tracking accuracy and reliability of the tracking system.

By Kong *et al*. (2014) had proposed a clustering-based system for detecting unanticipated intrusions. In their system by using a competition scheme, dynamic clusters are created frequently repeatedly as the event evolves. Cluster Head Election Window (CHEW) is established by nodes once they detect an object related event in the monitoring area. The key parameters of CHEW function are residual energy and distance to the target that is node with high energy and short distance to the target means that it has a small CHEW). Such node would win the competition and consequently creates a cluster to monitor the target. This process is repeatedly performed as the target moves. While creating new clusters other clusters that are unable to detect the target are terminated to save energy. The proposed system can be used for single and multiple target tracking. Nonetheless, as dynamic clustering process presented in the proposed system is activated each and every time the target moves it contributes to extra overhead. Moreover, electing a new CH requires disseminating advertisements to the other nodes to declare its election. Consequently, the network performance and lifetime are affected drastically. Furthermore, sensing coverage hole is a serious issue in WSN Kanno *et al*. (2009). When the target moves and depending on its speed, the target may temporarily be missed as it enters uncovered area (hole). This is very critical issue in sensitive applications such as intruder tracking. Hence, the reason why considering a recovery technique when designing target tracking system is important. The proposed system does not include a recovery mechanism to recapture the lost target. In the sense of utilizing prediction approach to improve target tracking (Deldar and Yaghmaee, 2011) had designed a prediction-based clustering algorithm for target tracking which involve two stages; clustering stage, during which elected CHs create their clusters by broadcasting hello messages to the other nodes and tracking stage where three members nodes are selected by the CH detecting the target to perform the sensing task. A tracker node is chosen according to its distance to predictable position of the target and its residual energy. The tracker nodes continuously update their CH about their distance to the moving target. Accordingly, the CH computes the location of the target using trilateration process (this technique was used in several research works on localization (Huang *et al*., 2014; Oguejiofor *et al*., 2013). The CH then anticipates the next position of the target and reselects another three nodes according to the new anticipated position before the target approaches. The selection of the new nodes is done according to their distance to the anticipated position and their residual remaining energy. However, besides suffering from high energy consumption due to a large amount of packets sent to the CH in every measurement period, the tracking accuracy is of concern as only three nodes are selected, considering the speed of the target.

By Bhuiyan *et al*. (2010) had proposed Prediction-based Energy-efficient Target tracking protocol (PET) for target tracking in terms of sensing quality and communication energy consumption. To track the target step by step, two-dimensional Gaussian distribution was used to precisely predict the target's future location. Planarization technique was used to follow the target in a special region known as a face. This technique can reduce the traffic volume and the time for neighbor discovery operations and thus, improving the network lifetime. Furthermore, to save energy, a wakeup strategy was introduced for early activation of the suitable nodes that are close to the target's predicted location. Nevertheless, in PET when the node's sensing range is short the target missing rate is high. It is because of that with shorter sensing range, more coverage hole would be existed and hence, higher probability to lose the target is Shen *et al*. (2013) had proposed efficient prediction-based tracking scheme where the network of the monitoring area is divided into regions using the Relative Neighborhood Graph (RNG) algorithm. It uses the target trajectory and improved Least Square Method (LSM) (Wolberg, 2006) to predict the target future path. In their scheme, target tracking process is initially start by activating only nodes located at the border of the monitoring area, so as to detect any physical event such as an intruder. When, the target is sensed in a region, nodes in that region will be kept active while the rest nodes in all other regions are turned into sleep mode. The region where the target is located would invoke the prediction function to estimate the path of the target. LSM prediction function allows the activation of the nodes in the region where the target is anticipated to enter. However, in this mechanism, the target movement controls rate of the prediction function calls. As the proposed mechanism uses very complex prediction function; hence, as the target moves fast it can be invoked many times to predict the target's position and therefore, consumes much energy in addition to that the notification delivery time would be of concern. For the purpose of balancing the energy consumption and the accuracy of the target tracking, (Teng *et al*., 2010) had proposed a nonmyopic rule that is based on the state prediction and the future tendency of the target, to activate the cluster that is located nearby the target only. Also, variational filtering algorithm was utilized which is capable of providing accurate tracking. The active cluster member nodes use a binary proximity observation model which helps in reducing the intracluster communications and energy consumption. Even though binary sensor nodes consume less energy and that binary outputs contribute to the significant reduction in the size of data traffic transferred to the sink they do not provide precise estimation of the location, direction or velocity of the evolving event as only one-bit data is generated to inform on the presence or absence of the event.

Aiming at reducing the ratio of missing the target (Alaybeyoglu *et al*., 2014) had proposed a system with five algorithms for tracking targets with fast movement. Among them, Dynamic Lookahead Spanning Tree Algorithm (DLSTA) is responsible for dynamically forming trees along the predicted path of the target prior to its arrival. The root of the tree is the node that has the shortest distance to the target. In DLSTA, the node closest to the target is elected as a root node. By estimating the speed, direction and location of the target, the root node builds its clustered tree. The number of trees increases according to the speed of the moving target. Several prediction techniques such as linear, kalman and particle filtering were used to predict the target's next state and enhance tracking accuracy. However, as the mobility profile of the potential target is predefined, the performance of tracking tree gets affected whenever there is a change in the mobility behaviors of the target. This issue can be alleviated by utilizing a dynamic adaptation procedure, called Message Tree Adaptive (MTA) (Chen *et al*., 2010) which can improve the tracking tree when the predefined mobility profiles and the target movement behaviors do not match and correct the events changing rate. Nonetheless, as the tree size increases, very high overhead is incurred by this procedure due to the update cost of the tracking tree. Thus, more adaptive information is required to be sent along the tracking tree which can cause congestion and latency in delivering the notification reports to the sink.

By Jiang *et al*. (2013) had proposed a protocol, called Probability-based Prediction and Sleep Scheduling (PPSS) for energy-efficient target tracking where kinematics rules and probability theory were utilized in designing the target prediction technique which helps in defining the next position of the target. To save energy, PPSS selects the nodes to awaken according to the prediction results. However, in PPSS, it is assumed that the movement of the target follows a smooth curved trajectory; hence, sudden changes in the target direction would not be handled. Consequently, computing the target location would take long time which limits the tracking performance in terms of accuracy.

For improving localization and prediction of a moving target with large acceleration (Chen *et al*., 2011) had proposed a practical Distributed Sensor Activation algorithm (DSA2) which enables reliable tracking with the simplest binary-detection sensors. In DSA2 with respect to the behaviors of the adjacent neighboring nodes, all nodes in the monitoring area are activated with a certain probability to detect targets or sleep to save energy. Though, DSA2 is inefficient in recapturing the missing target as only nodes that are in the sensing mode can detect the target.

Tracking multiple targets is more challenging than tracking a single one due to the variations in speed and directions of the targets. In regards to tracking multiple targets, data association is an issue. It concerns the correct correspondence between measurements and target tracks. In some scenarios, wrong measurements can be obtained by nodes, leading to high target missing rate. Data association can be solved by using munkres algorithm (Parmar and Zaveri, 2012). Earlier and aiming at tracking targets that have a correlated motion using binary nodes (Cao *et al*., 2010) proposed a system of several algorithms including two target group localization algorithms, dynamic reporter node selection and redeployment control algorithms and a fault-tolerant target group detection algorithm which is responsible of handling the measurement errors in the network. Target group localization algorithms are Hull and Cir algorithms for approximating the course of targets. By calculating the convex hull based on Graham scan algorithm, Hull algorithm is considered very accurate; nevertheless, it has high complexity. On other hand, besides that Cir algorithm forms a circle covering the convex hull but it is inaccurate. The closest node to the plus node is selected as reporter to save energy. As the proposed system considers tracking targets with correlated motion, speed and direction, it would not be appropriate for scenarios where targeted events may split, merge or even overlap such as gas leakage or fire and so on.

Our conclusion is that as target tracking is the process of detecting and localizing a target as it moves in the monitoring with cooperative processing; thus, the accuracy of tracking depends on the employed technique and the number of nodes tracking the target. As the accuracy of tracking depends on the number of active nodes in the area at the time the target is discovered, the more nodes involved in tracking the target would result in more accurate tracking; yet cause high energy consumption and communication overhead. These undesirable consumptions and overhead can be reduced by reducing the number of active tracking nodes. However, that depends on the application requirements and its acceptance to the tracking error. Most of the systems developed for target tracking attempt to lessen the energy usage while improving the tracking accuracy through various strategies including clustering, prediction of target future location, utilizing particular network structure and using binary sensor nodes. There are many factors that restraint the tracking and can result in missing the target. These include presence of obstacles, network energy holes due to nodes energy depletion, coverage holes, communication failures, unexpected change in the velocity and direction of the target, incorrect estimation of the target current location, long delay in computing the prediction of the target future location. Network efficiency has major impact on target tracking. Increasing the exchange of the sensing information can cause bottleneck and congestion in the network. Congestion may happen when single target tracking and multiple targets tracking drive more nodes to exchange data concurrently, leading to higher traffic competing for the sink in the network. Systems that consider controlling traffics besides tracking a target suffer from heavy overheads and high delay in data reporting. As the captured data about a target must be transmitted and processed timely it requires reliable techniques for processing the target related that would reduce potential errors which lead to incorrect decisions. Target tracking systems must be capable of identifying the target, localizing and tracking its current and future position and anticipate its future movements and behaviors.

CONCLUSION

The current developed event detection and tracking systems have several limitations that make them not suitable or efficient to be utilized in smart homes. These limitations include dealing with direction changes and varying speeds of an evolving events, node fault tolerance, energy consumption, missing of target, tracking precision, dynamicity of the target and prediction accuracy. The situation becomes difficult with the detection and tracking of multiple targets. Therefore, more realistic solutions are highly needed. Furthermore, these systems assume that the phenomenon will continue evolving with same speed and direction for the future instants and process historical data to infer subsequent evolvement of the event. These assumptions are not realistic for smart homes. Therefore, we aim to propose a reliable smart system for detecting and tracking of moving object (in case of robbery for example) by collecting and analyzing the related data during their development in time and space when there are environmental changes or irregular events and decide on appropriate safety procedures, according to the event properties such as position, shape, size, direction and speed that describe the behavior of the event.

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