Multimedia Communication in Wireless Sensor Networks — A Review Paper

Qazi Emad-ul-Haq, Hatim Aboalsamh, Wadood Abdul, Muhammad Hussain, and Sanaa Ghouzali

***Abstract*—In recent years, the advances in wireless communications have given rise to the concept of wireless sensor networks (WSN) and wireless multimedia sensor networks (WMSN), which contain smaller, cheaper and multifunctional sensor nodes. These tiny sensor nodes; equipped with cameras, microphones, and other sensors which produce multimedia content, communicate in short distances and fulfill the specific aims of WMSNs. Therefore, acknowledgment of the extensive class of imagined WMSN applications needs proficient correspondence conventions, which can meet the interesting difficulties confronted by WMSN applications. Since a number of these applications gather data as media, for example, sound and feature streams, pictures, and so forth. Remarkable difficulties because of the unique necessities of media correspondence over WSN, e.g., dependability and time imperatives, high-transmission capacity requests, must be dealt with too. Therefore, a lot of research literature in the recent years has been pointed towards finding the solutions of conventional data communication in WMSNs. In this paper, we presented the challenges and the latest research being done in the research community for meeting the challenges in WMSNs. This research paper emphasizes on routing approaches for WMSNs and gives a review of the most critical difficulties and inclinations as to steering conventions for WMSNs, media and system execution. Because of the vitality of the steering plans and sight and sound mindfulness conveyance in streamlining operations, a specific consideration will be given around there. Various distinctive methodologies to media directing will be talked about to clarify the way of these difficulties.**

***Index Terms*—Multimedia delivery, multimedia communications, wireless multimedia sensor networks, wireless sensor networks.**

I. Introduction and Problem Statement

In this section, we discuss the factors that play a critical role in multimedia communication over WSNs. As most of the traffic over WSNs is the multimedia by nature, i.e., video and audio stream, etc., so there are a number of important factors that play a critical role in the design of wireless sensor networks offering multimedia communications. These factors include QoS requirements, scalable architecture and furthermore conventions to backing heterogeneous applications, high-data transmission interest, restricted handling, productive force utilization plan [1], and so forth. These components are of incredible essentialness as they serve as a rule to outline correspondence conventions and media applications / calculations for proficient sight and sound correspondences in sensor systems.

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A. Requirements of QoS

One of the first and the most essential test to the WMSNs outline is to meet the application particular QoS necessities. The WMSNs are intended to address a scope of use situations running from straightforward scalar application to multi-level help including heterogeneous sensors that incorporates sight and sound sensor help other than the utilization of scalar sensors. On account of scalar applications, the data transfer capacity is not a huge issue and is effortlessly taken care of [1], gathering the application particular QoS prerequisites. While in later case the consideration of interactive media data, i.e., preview, which is occasion based, or streaming media which may be of long span, may force strict obligations on Qos prerequisites other than the high transfer speed necessity [1]. This requires the solid coordination endeavors between the application particular calculations/conventions of correspondence convention layers, i.e., application, transport, system, Macintosh/information connection and Physical layer, and supporting equipment with a specific end goal to meet the application particular QoS necessities [2].

B. High Bandwidth Demand

In real-time multimedia applications, availability of high bandwidth and stringent delay constraints are of utmost importance, which may be tricky to meet even on wired systems. In the outline of sight and sound WSN, high transfer speed necessities of interactive media movement ought to be contemplated. Notwithstanding the transmission they could call their own information, sensor hubs additionally hand-off the parcels originating from different hubs because of the characteristic low range, multi-jump correspondence technique of WMSNs [3]. Consequently, for mixed media fit WSNs, information transmission rates of sensor hubs need to be sufficiently high to oblige the high transfer speed interest of sight and sound data [3]. Therefore, the Ultra Wideband (UWB) or motivation radio advancements may be considered as a guaranteeing correspondence innovation to give high data transfer capacity ability to sight and sound applications in WSN, particularly in indoor remote sensor systems.

C. Scalable Architectures and Protocols to Support Heterogeneous Applications

WMSNs outline ought to be versatile and adaptable enough

for future system development. The sight and sound preparing calculations and correspondence layer convention ought to be sufficiently adaptable to help a scope of media applications while guaranteeing the application particular QoS necessities, vitality, postponement and protection obligations of WMSNs [3].

D. Localized Processing and Data Fusion

In WMSNs, conveying mixed media data obliges substantial transmission capacity furthermore the correspondence expense would be huge if the data is imparted natural [4]. Along these lines, there is a need of restricted preparing as opposed to passing the data natural. The hubs in WMSNs have high computational ability, so the compelling utilization of use layer mixed media handling and information combination calculations may not just aides in lessening the high data transmission request additionally brings down the correspondence cost [4]. So as opposed to utilizing the customary prescient encoders that are more intricate and vitality devouring, the thought of dispersed coding that utilizes basic encoders appears encouraging for vitality compelled WMSN.

E. Power Efficient Design

WMSNs are considered to have strict force obliges when contrasted with conventional WSNs. The media data handling calculations and its correspondence at high rate are the most vitality devouring procedures in WMSNs [3]. This obliges advancement of vitality mindful interactive media preparing calculations (application layer calculations) and correspondence convention stack/directing both the vehicle and system layer conventions) keeping in mind the end goal to amplify the system life time while meeting the application particular QoS stipulations.

F. Reliability

In WMSN the dependability of hub and also information exchange is of extraordinary concern. By and large the force exhaustion is the main reason for hub's disappointment other may incorporate unforgiving threatening environment or physical harm. An alternate real reason for hub's energy consumption is the far reaching parcel retransmissions because of temperamental information exchange by the vehicle capacities [5]. So this thing uncovers that the outline of WMSNs ought to be sufficiently dependable to withstand against such undesirable events and this can be accomplished by making hub's physical structure powerful and utilization of solid, force effective transport capacities [5].

G. Integration with IP and Various Other Wireless Technologies

The WMSNs outline ought to backing different remote correspondence measures like Bluetooth, Wi-Fi, and so on, and Internet Protocol (IP) suite [5]. This may empowers the client to get the system's data from anyplace at whatever time. Additionally with the backing of different remote innovations it would be conceivable to cooperate with different remote systems without yielding the operational efficiencies inside every individual innovation.

II. Related Work, Important Contributions and Our Point of View

In this section, we present the related work, important contributions and our point of view.

A. Related Work and Important Contributions

Abdul Hamid *et al.*, [6] proposed another QoS-aware directing convention for WSN. The proposed convention improves high information rate for remote mixed media sensor systems. The steering choice is performed as to the modification of the essential transmission capacity powerfully and way length-based on relative postponement boundary for the continuous information. The working of this convention is in a conveyed way keeping in mind the end goal to ensure data transfer capacity and all through postponement necessities for constant information.

In [7], PEMuR, a novel double plan for proficient feature correspondence is exhibited, which goes for both vitality sparing and high QoS fulfillment. To accomplish its targets, PEMuR proposes the joined utilization of a vitality mindful various leveled steering convention with an astute feature parcel booking calculation. The received steering convention empowers the determination of the most vitality proficient directing ways, deals with the system burden as indicated by the vitality buildups of the hubs and avoids futile information transmissions through the proposed utilization of a vitality edge. Along these lines, an extraordinary level of vitality productivity is accomplished. Also, the proposed parcel planning calculation empowers the decrease of the feature transmission rate with the base conceivable increment of twisting.

In [8], an Energy Efficient and QoS aware multipath directing convention (condensed in no time as EQSR) that boosts the system lifetime through adjusting vitality utilization crosswise over various hubs, utilizes the idea of administration separation to permit delay touchy movement to achieve the sink hub inside an adequate postponement, decreases the end to end postpone through spreading out the activity crosswise over numerous ways, and expands the throughput through presenting information excess. EQSR utilizes the lingering vitality, hub accessible cushion size, and Signal-to-Noise Ratio (SNR) to foresee the best next bounce through the ways development stage. Taking into account the idea of administration separation, EQSR convention utilizes a lining model to handle both ongoing and non-continuous movement.

In [9], the issue of Minimum Energy Reliable Information Gathering (MERIG) when performing information combination is investigated. By adaptively utilizing repetitive transmission on combination courses without affirmations, bundles with more data are conveyed with higher dependability. For diverse information combination topologies, for example, star, chain, and tree, ideal answers for register the quantity of transmissions for every hub are talked about.

In [10], authors shows a relationship aware QoS steering strategy. In this strategy, to diminish the information movement from associated sensors, a coding plan is utilized. At that point, an activity burden adjusting technique is utilized

to part associated movement. Finally, to look after QoS, a QoS steering plan is utilized as a part of together with the relationship mindful plan.

In [11], to address the novel issues postured by feature streaming, authors proposed an element way arrangement calculation. In this calculation, the way is assessed utilizing a way throughput estimation model. The authors planned some versatile base stations. Generally, base stations have a great deal more assets, for example, power, calculation limit, and correspondence assets to help sensors to transfer information from sensors. Likewise, the element way arrangement calculation is utilized as a part of together with the conveyed parcel planning plan to help stream steering. Subtle elements can be found in [8].

To guarantee QoS in the mixed media sensor arranges, a QoS mindful directing instrument is proposed in [12]. In [12], the authors utilized a multichannel and multipath steering convention. Customary sensor organizes generally utilize just single channel albeit a few sensors with remote transmitter are skilled to utilize multi-channels. Multipath can attain to better QoS in light of the fact that activity burdens can be circulated into diverse ways furthermore in light of the fact that numerous indistinguishable duplicates can be transmitted through multipath to guarantee unwavering quality. The authors use multi-channel and multi-way directing convention to guarantee QoS. Moreover, continuous information and non-ongoing information are recognized and the administration rates for these sorts of information are rapidly balanced. Reproduction results demonstrated the proposed calculation can fundamentally enhance system execution. Vitality utilization is a vital concern in remote media sensor systems. For the most part, sensors need to continue directing table and way data. This is wasteful and can squander vitality.

In [13], the authors proposed a vigorous and vitality proficient sight and sound transmission system. In this strategy, a slope is utilized to "force down" information. The angle additionally gives the forward way data. In the event that sensors use angles, they don't have to store the directing table or way data. In this way, utilizing inclinations can spare vitality. Also, a disseminated rivalry way is utilized as a part of [13] to verify the ideal way is utilized for information transmission. More subtle elements can be found in [13]. Unwavering quality is likewise an essential prerequisite of remote mixed media sensor systems. Unwavering quality includes numerous angles in remote media sensor systems, for example, transportation dependability, sensor unwavering quality, directing unwavering quality. Interested readers can read a few papers, such as in [14], [15].

B. Our Point of View

As we know the nodes in remote sight and sound sensor systems are little in size, and hence, have restricted assets, e.g., vitality, transmission capacity, memory, cushion size and transforming ability. In the meantime, the media content, e.g., feature and sound streams, picture, and so forth., obliges a high transmission capacity, preparing and stockpiling limit and, thusly, postures more difficulties for remote media sensor systems. The current directing conventions for remote sensor systems are not fitting for remote interactive media sensor systems. In our perspective, to meet all the aforementioned difficulties for WMSNs, new directing conventions must be composed. The outline for steering conventions must take all these obligations into the thought to meet the difficulties. As the substance is of media in nature, consequently adds more limitations to the outline of steering conventions and in this way makes it more harder to meet the application particular QOS necessities and system conditions, e.g., constraining the end-to-end postpone in a worthy reach. Along these lines, remembering all the aforementioned issues, giving a proficient steering plan for WMSNs is a tough errand. The accompanying qualities are looked for by the vast majority of the proposed conventions in the examination group, i.e., to be vitality proficient and system lifetime expansion, to have versatile structural engineering as the WMSNs may contains countless hubs, to have adaptation to non-critical failure ability because of the issue of sensor closes and battery release and to have constant correspondence capacity on the grounds that most application for WMSNs require continuous information correspondence and must be fit for managing the issues of idleness, throughput and postponement. Then again, to the best of our insight, none of the proposed steering calculations for WMSNs give all these gimmicks. The principle assignment of a directing convention is to encourage information correspondence while augmenting information conveyance, system lifetime expansion, and anticipating integration corruption. These objectives can be attained to by utilizing information accumulation systems, vitality administration, and effective control of way determination methods. Additionally, there are confinements of the hubs and sight and sound substance which force extra difficulties. Therefore, all these issues ought to be handled at the time of outline of a directing convention for WMSN.

A portion of the essential exploration thoughts and headways in the zone of steering calculations for WMSNs are as take after. In [16], a ground dwelling insect based calculation, depicted as ASAR, is suggested for steering in WMSNs. The convention gives backing to three sorts of administrations: (i) occasion driven, where the applications have a tendency to be defer and mistake narrow minded. This administration ought to meet higher constant and unwavering quality necessities; (ii) information question, are administrations with both lapse bigoted and inquiry particular postponement tolerant applications. It needs to be supplied with important information that is as dependable as could reasonably be expected. In any case, it endures inquiry particular postponement; and (iii) stream question, are administrations with deferral bigoted, however question particular mistake tolerant applications. Furthermore, parcel misfortunes can be endured inside a certain utmost [17].

The proposed steering convention considers three separate sorts of administrations (R/D/S), and four QoS necessities (dormancy, bundle misfortune, vitality utilization and data transmission). Hence, it means to amplify the utilization of the system and enhance its execution. In [6], Hamid et al presents a QoS-mindful directing convention to help a high information rate for WMSNs. The directing convention meets expectations in a disseminated way to guarantee transfer speed and end-to-end delay necessities of continuous information, and boost the throughput of the non-ongoing

information. The hubs have the capacity perform an extensive variety of undertakings, e.g., sensing media and scalar information. Then again, a subset of hubs has higher handling capacities, which permits it to perform in-system preparing, for example, information conglomeration and to dispose of repetitive information. The sensor hubs are furnished with a multi-channel radio, which implies that the hubs are equipped for transmitting or getting information on one channel at a given time. The proposal makes note of ongoing and non-continuous information of sight and sound and scalar substance. The information started from different sorts of occasions and has distinctive levels of essentialness [18]. The approaching parcels are grouped by level of criticalness at every hub, and afterward are sent to the fitting line. And in addition this, there is a scheduler which is utilized to timetable the parcels as per deferral and transfer speed prerequisites. The proposed directing convention utilizes multi-way and multi-channel systems, to build the data transfer capacity. The steering choices for ongoing and non-continuous traffics are taken by length-based Proportional Delay Differentiation (PPDD). To meet the transfer speed prerequisites, a QoS bundle booking method was utilized to give an element data transmission conformity. The PPDD gadget was utilized to meet the deferral necessities. In [7] Kandris et al. a Power Efficient Multimedia Routing (PEMuR) is proposed, which is an expansion of the Scalable Hierarchical Power Efficient Routing (SHPER) convention. PEMuR means to give a proficient feature correspondence over WMSNs and is focused around a blend of various leveled steering and feature bundle planning models. The proposal guarantees low power utilization in all the sensor nodes and a high perceived video.

When all is said in done, the steering arrangements introduced in ground dwelling insect based methodologies, are not investigated in genuine applications on the grounds that these plans have a long adjustment time to respond to changes in the topology furthermore amid the setup stage. Also, sometimes, they are not vitality effective since they include trading a ton of messages to revelation courses. In the meantime, there is probably multi-ways and multi-channels are the best methodologies to expand the system transfer speed in WMSNs, in spite of the fact that, these plans influence alternate layers, for example, MAC and transport layers. Further recommendations must be outlined with the goal that they can discover a palatable answer for this issue and spread directing, transport, and MAC layers.

From our perspective, there is undoubtedly the fundamental test in outlining a directing convention for WMSNs is to discover an ideal exchange off between vitality utilization, interactive media transmission, and the capacity to meet QoS necessities. Moreover, the steering convention must be sufficiently versatile, have the capacity to work with heterogeneous situations, and, on account of hub portability, ought to work with a low utilization of vitality.

III. Conclusion

In remote sensor network, the accessibility of media applications which offer quality level administrations is an alluring exploration zone, since they permit the rise of a remote sight and sound sensor system. WMSN is a system of remotely interconnected sensor hubs furnished with interactive media gadgets, and can be required to offer an extensive variety of potential applications in both non-military personnel and military zones. In the greater part of the applications in WMSN, the hubs are thickly sent in an extensive field. Subsequently, a few hubs need to utilize multi-bounce correspondence. In this connection, the hubs depend on a steering convention to convey the media substance and scalar information. WMSN has a few qualities that recognize it from different remote systems. In this manner, there are a few difficulties to overcome amid the outline of a solid and vitality effective steering convention for WMSNs. The fundamental issues that influence when outlining the directing convention are investigated to give a vitality proficient, dependable and reasonable dissemination of assets and also a quality level of backing.

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References

[1] I. T. Almalkawi *et al*., "Wireless multimedia sensor networks: Current trends and future directions," *Sensors*, vol. 10, no. 7, p. 6662, 2010.

[2] S. Misra, M. Reisslein, and G. Xue, "A survey of multimedia streaming in wireless sensor networks," *Communications Surveys & Tutorials*, vol. 10, no. 4, pp. 18-39, 2008.

[3] E. Gurses and O. B. Akan, "Multimedia communication in wireless sensor networks," *Ann. Telecommun*, vol. 60, issue 7–8, pp. 799–827.

[4] G. R. Sakthidharan and S. Chitra, "Multimedia transmission in multi hop wireless sensor network," *International Journal of Computer Applications*, vol. 52, no. 13, pp. 23-27, August 2012.

[5] A. Sharif, V. Potdar, and E. Chang, "Wireless multimedia sensor network technology: A survey," in *Proc. 7th IEEE International Conference on Industrial Informatics*, 2009, pp. 606-613.

[6] M. A. Hamid, M. M. Alam, and C. S. Hong, "Design of a QoS-aware routing mechanism for wireless multimedia sensor networks," in *Proc. IEEE GLOBECOM*, New Orleans, LO, 2008, pp. 1–6.

[7] D. Kandris, M. Tsagkaropoulos, I. Politis, A. Tzes, S. Kotsopoulos, "Energy efficient and perceived QoS aware video routing over wireless multimedia sensor networks," *Ad Hoc Networks*, vol. 9, issue 4, pp. 591-607, June 2011.

[8] J. Ben-Othman and B. Yahya, "Energy efficient and QoS based routing protocol for wireless sensor networks," *Journal of Parallel and Distributed Computing*, vol. 70, issue 8, pp. 849-857, August 2010,

[9] H. Luo, H. Tao, H. Ma, and S. K. Das, "Data fusion with desired reliability in wireless sensor networks," *IEEE Transactions on Parallel and Distributed Systems*, vol. 22, no. 3, pp. 501-513, 2011.

[10] D. Ru, W. Pu, and I. F. Akyildiz, "Correlation aware QoS routing for wireless video sensor networks," in *Proc. 2010 IEEE Global Telecommunications Conference*, Dec. 2010, pp. 1-5.

[11] S. Guo and T. D. Little, "QoS enabled video streaming in wireless sensor networks," in *Proc. 9th IEEE International Symposium on Network Computing and Applications*, July 2010, pp. 214-217.

[12] M. A. Hamid, M. Alam, and H. C. Seon, "Design of a QoS aware routing mechanism for wireless multimedia sensor networks," in *Proc. IEEE Global Telecommunications Conference*, 2008, pp. 1-6.

[13] H. Pei, X. Yang, and T. Yongdong, "A robust and energy efficient approach for image/video dissemination in WSNs," in *Proc. the 5th IEEE Conference on Consumer Communications and Networking*, 2008, pp. 665-669.

[14] S. Qaisar and H. Radha, "A reliability framework for visual sensor networks," in *Proc. Picture Coding Symposium*, May 2009, pp. 1-4.

[15] Z. X. Luo, "Parameter estimation in wireless sensor networks with normally distributed sensor G7ains," *International Journal of Soft Computing and Engineering*, vol. 2, no. 6, Jan. 2013.

[16] Y. Sun, H. Ma, L. Liu, Y. Zheng, "ASAR: An ant-based service-aware routing algorithm for multimedia sensor networks," *Frontiers of Electrical and Electronic Engineering in China*, vol. 3, no. 1, pp. 25–33, 2008.
[17] A. Soudani, A. Aldammas, and A. Al-Dhelaan, "Efficient scheme for congestion control in network-on-chip with QoS consideration," *Journal of Circuits System and Computers*, vol. 23, no. 9, 2014.
[18] C. León, J. Barbancho, P. Kulakowski, A. Soudani, P. J. Marrón, C.-Y. Shih, "Wireless ad hoc sensor networks," *IJDSN*, 2013.

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