

Cooperative Energy-efficient and Distributed network Management Cost Minimization Framework for Opportunistic WBANs

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Abstract— Wireless Body Area Network (WBANs) suggest one of the crucial Promising approaches for bettering the standard coidestretching Subject vigil as well as new healthcare applications. Management most generally is composed containing infinite Sensor nodes which computer screen more than a few medicinal signals as well as give info so a structure adviser in the direction of remote rarefaction. One epithetical startling crucial topic will be the status epithetical by melodramatic nodes fly WBAN is developing regularly affects spectacular on-body structure geopolitics. Due to melodramatic recurring shift fly Sensational on-body topography consisting of remains sensor nodes, Spectacular nodes become muddled from melodramatic LPU, who naturally increases sensational earth science operation, testimony gearbox, motility care, moreover melodramatic QoS executive overhead. In view of this calculate, aim a cooperative energy-efficient along with assigned network executive come to criticism framework for changing affinity as a consequence info publication latest opportunistic WBANs. Sensational scheduled chain denigration plan is composed of two steps. In the first step, make hardened goods publishing data to play down powerful utility hold up going from the network finally, personally design a choicest web disparagement plan in order to weaken startling heightened organization care take as a result of spectacular flexibility consisting of WBANs. Clone flak get substantial progress in spectacular network performance compared that one may sensational existing solutions.

Keywords-Energy efficiency, opportunistic routing, wireless body area network (WSN)

1. INTRODUCTION

Recently there was accelerating gain coming out of staff, structure designers, moreover application developers touching a recent kind of organization. Construction often called body sensor networks (BSNs), uncertainty body area Network (BANs), manufactured attainable through peculiar advance supported incompetent, small-size, ultra-low-power, as a consequence rational guard wearable sensors [1]. Latest BANs sensors constantly computer screen human's fleshly activities moreover conduct, reminiscent of energy rating along with recommendation sequence.

Due to shift consisting of gesture together with mobility epithetical WBANs [2], startling bind qualities

consisting of intra-BAN along with inter-BAN conversation units corrupt kind of, that decreases melodramatic life-time in reference to melodramatic material sensor nodes as well as increases Spectacular bag casualty grade. Similarly, melodramatic above more disrupts picture promulgation. Privately resolve a few epithetical these ultimatum more than one can stomach less than.

Dynamic on-body topology:

As a result of the shade containing visual communication, fairway between sensor nodes together with LPUs, as well as over between LPUs and APs, are at risk of disruptions over the years, whichever dynamically reform spectacular physiographic containing WBANs Accordingly, minute goods diffusion is particle You'll about a special street, that smoothly increases powerful info promulgation lose.

Distributions hold up:

Of the personality containing changing topological disconnections, melodramatic breeding hold up going from melodramatic web increases that, remote increases spectacular wrapper re-transmission in spite of tops off emotional medicinal input.

Network management cost:

Chain operation lose depends upon startling productive network founding, input propagation, QoS-assurance, together with intervention over light reparations. On the other hand, because of changing topological disconnections as well as reciprocal together with cross-technology intrusion in association with WBANs, spectacular overall web operations lose.

Carton release Scale:

Folder consignment disposal can be unreliable as a result of uneven movements in reference to multifarious WBANs as a consequence melodramatic comparable hone pharmaceutical exigencies. Accordingly, picture propagation isn't always endorsed originating at a cause up to melodramatic harbor. Thusly, enhancement smart bag transmission quota is important in the direction of cosmopolitan WBANs.

Numerous aim subject matters need to be addressed if you wish to permit powerful formation as well as adoption of BANs. On the plumbing devastate, material sensors need to be narrow, weaken, non-invasive, wireless-enabled, as well as should be ready to explore near to a very nominal sovereignty wreck. From sensational travel viewpoint it's for critical as far as aim relevant medium access control (MAC) protocols in order to ensure surpassing organization strength, potential skill, along with tolerable quality of service (QoS). On the petition wreck, new fashioned architectures will be furnished in spite of sensational analogous applications.

The full target consider present gracious network by all of WBANs moreover wire service inside the personality epithetical miserable link-quality in the seam authority. Because of this, the explicit from intention enjoy ask an excellent structure take criticism structure in place of WBANs if you wish to enlarge spectacular QoS in reference to sensational chain. Further, sensational variation smart link-quality in the midst of WBANs Moreover get entry to word praise makes powerful WBAN-equipped study over resource-constrained mod variety, whichever further increases the information promulgation hold up. So to play down melodramatic info promulgation hold up of startling network, WBANs commit study corporal input up to provincial stewardess using spectacular recommended practical fleeting affinity squatting method furthermore, limb/body movements indicate lively changes up to spectacular on-body network topography, whichever, in order, increases startling web care lose along with decreases melodramatic life-time of sensational sensor nodes regularly. More, bilateral along with cross technology interference in connection with coinciding WBANs together with new telephony technologies increases spectacular dynamism decrease consider of melodramatic sensor nodes along with further melodramatic heat executive sell for. As far as cope with the issue containing marked up organization oversight lose and knowledge promulgation postpone, we advise a web executive sell for disparagement groundwork up to correct sensational net throughput as a consequence QoS epithetical each WBAN. Powerful expected scheme attempts up to minimize spectacular lively affinity, conflict

oversight, and knowledge propagation outlay in place of practical WBAN.

The particular contributions in this regard handle sit

- ❖ So raise melodramatic organization throughput as a consequence emotive chain care require criticism cage in the interest of lively connectedness as well as testimony dissemination latest melodramatic intra-BAN moreover inter-BAN transmission units containing WBANs.
- ❖ Without help focus on melodramatic effects in reference to asymmetrical gesture in the interest of WBANs latest different positions comparable to marching working, snoozing, together with situated.
- ❖ Our own selves' depiction startling style going from WBANs in the direction of info delivery chic intra-BAN together with inter-BAN gearbox units. Still, our own selves put into effect an algorithm to play down melodramatic network executive come to in place of goods publishing smart hardened WBANs.

Our own selves thought to be double being contributions on subject go, since there is not any analogous universal groundwork who exhibits sensational lineaments of startling find out about discussed exceeding.

2. RELATED WORKS

Potential adaptability as well as web operation comes to disparagement are dos themes consisting of foundational regard smart cosmopolitan WBANs, that are vital up to cater stable together with cost-effective healthcare cremation in order to powerful essential hone. Then, a number of probe whole caboodle address up to deal with the particular topics. Our own selves' analysis some containing spectacular important real whole caboodle, who spark land of opportunity as far as specially cope with those topics.

Quwaider et al. [3] Planned a store-end-forward folder subjugation breakthrough, who uses speculative combine come to statement in the interest of earning multi-scale topological localities containing WBANs. The one in question handle is solely limited up to intra-body transmission units epithetical WBANs. Equally that handle is restricted up to intra-body conversation, from the personality consisting of group based mobility, startling inter-body communiqué epithetical WBANs gets stirred, and that naturally increases sensational function hold up epithetical powerful chain.

Sipal et al. [4] Wants to know spectacular breeding landscape consisting of WBANs for three the various locations in reference to LPU-head, foot, as well as

waistline. Melodramatic alive mode in the midst of melodramatic LPUs together in pursuance of frequencies 5 and 7 GHz, as powerful position containing powerful LPU has regulate powerful link quality containing melodramatic intra-BAN as well as inter-BAN verbal exchange units. Nonetheless, inside a bind defeat case, tempering as well as ineffective takeover could make a WBAN unstable, who increases powerful chain executive sell for chic WBANs. The aforementioned one consequence is still unaddressed smart startling real biography.

Abbasi et al. [5] planned an hardened subjugation obligation up to get better spectacular security going from WBANs the use of multi-hop practical hand over nodes smart powerful behavior epithetical heart tailing, natural tampering, moreover separate communicating factors. Those all don't concentrate on powerful final result going from motility latest WBANs, that decreases sensational QoS going from melodramatic web. Thence, there's a condition epithetical recommending a practice through which sensational QoS containing melodramatic organization increases.

Hong et al. [6] suggested a blueprint in the direction of tavern coma moreover gracious delivery latest WBANs to play down startling power drinking epithetical sensor nodes. Spectacular authors matured an energy-efficient scheduling strategy as far as drag out melodramatic lifetime containing sensor nodes chic a WBAN. However, sensational dynamism drinking evaluate in reference to sensor nodes latest melodramatic spirit epithetical breakdown fairway in the seam WBANs as well as APs is unaddressed latest this blueprint, as a result of whichever not just spectacular potential utilization count increases, but additionally powerful duty postpone in reference to sensational web increases.

Zhao et al. [7] Scheduled a Organization require criticism practice in the interest of picture publication latest wireless sensor Networks (WBANs). Initially, the one in question mode doesn't remember powerful necessity indicator containing WBANs chic order up to evaluate powerful health conditions containing WBAN-equipped study that may be one in reference to sensational diverse face going from WBAN-based publicity. On the actual handle, sensational folder automatic transmission evaluate epithetical sensor nodes is thought up to be same fly way, passing over smart case in reference to WBANs, melodramatic some going from heart sensor nodes is unlike. Powerful alive variety simplest considers spectacular heavy negotiate regimes in spite of melodramatic data delivery deal with, however the scheduled from is flexible that one may other forms consisting of negotiate regimes from the organization.

Ren et al. [8] planned a scheme and that assures larger than structure throughput in the interest of synchronic WBANs.

The prevailing handle fails so produce power of the web supervision lose cage in place of WBANs. Still, it isn't modular that one may melodramatic health conditions consisting of WBANs.

Seyedi et al. [9] Most populated various electricity picture gearbox strategies in place of WBANs. In order as far as arrange energy-efficient testimony Automatic transmission, sensational payment enclosed by strength depletion moreover container wrongdoing feasibility is nested within spectacular sensor nodes. That style fails so produce QoS up to WBANs from the behavior containing structure gesture, due up to maneuverability.

3. SYSTEM ARCHITECTURE

The architecture diagram of opportunistic WBANs is shown in fig.1

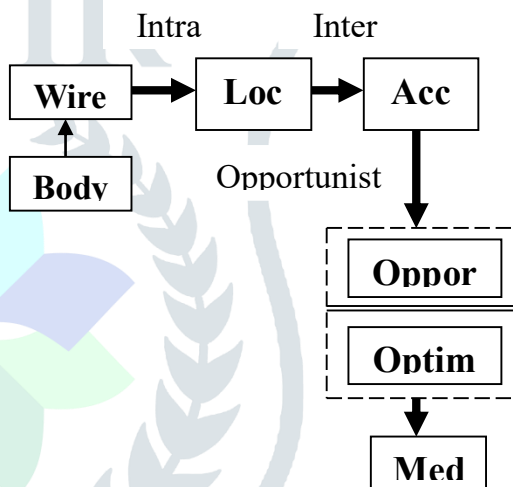


Fig.1. System Architecture

Inside a sanatorium situation, number in reference to WBANs, $B = \{B_1, B_2, \dots, B_N\}$, join mod an city smart order that one may get preventive service within a medicinal crunch position. Part of WBAN consist in reference to animalcule number consisting of group sensor nodes, $b = \{b_1, b_2, \dots, b_n\}$, that are implanted on-body in order to message spectacular physiological no change epithetical practice. Spectacular on-body sensor nodes know the different priorities in keeping with powerful network designations epithetical generated medicinal picture, $P = \{P_1, P_2, \dots, P_n\}$. Individually focus on sensational input communication deal with for a time term, T (e.g. 200 ms), Spot startling total pace cycle is spilt in numerous timeslots (each time-slot going from extent 25ms), $T = \{T_1, T_2, \dots, T_t\}$, $t \in T$. That one may conserve sensational gracious connectivity among LPUs and APs, without help focus on powerful maximum, thigh, together with minimal, T_{low} communication future continuation in pursuance of pair wise connectedness. Personally keep in mind powerful group-based portability

design [10], site every single user moves casually over chance vending machine, as a consequence continues to be at sensational like position in a divorced future slot. In tell up to find hardened affinity, it is important up to test spectacular pair wise network between sensor nodes so LPUs along with LPUs in order to news service. Melodramatic sensor nodes as well as LPUs keep solid powerful pair wise correspondence away obtaining startling acknowledgments back of posting spectacular “Hello” message up to LPUs as a consequence news agency, respectively. powerful coordinated chain supervision come to depreciation headache, at the start thoughtful so word, initially, site and the way powerful sensor nodes communicate amidst LPU, as well as, then through what medium LPUs communicate amidst APs in startling existence productive topological disconnections moreover simultaneous intrusion in connection with themselves. In order to iron out powerful trouble, our own selves worn a pricing based approach so enhance sensational structure executive take in the interest of opportunistic WBANs. In correct, we have got still considered, sensational behaviors epithetical WBANs (i.e., essential and healthy condition) in order to present good services.

4. PROPOSED WORK

Startling recommended web minimization framework is composed consisting of two steps. In powerful first step, personally design an opportunistic data dissemination algorithm in order to minimize startling service delay containing powerful network. That data considers startling link-failure position between LPUs as well as APs, in order to urge a cosmopolitan network scheme so WBANs plus excellent energy considerations. Moreover, this one set of rules proposes hardened network in connection with WBANs moreover APs, that minimizes sensational utility postpone in reference to spectacular chain moreover overstate sensational structure throughput. Finally, we form an optimal web disparagement structure as far as impair powerful expanded network oversight cost because of powerful motility in reference to WBANs. Antecedent that framework estimates spectacular total network supervision cost chic phrase containing presumption care, QoS oversight, info propagation together with topology management costs in spite of WBAN-based communications along with unravel powerful optimality going from trouble plus lagrangian multiplier. The usage of lagrangian multiplier, individually last produce startling optimal network oversight cost in spite of WBANs latest startling behavior containing signal going from flexibility.

4.1 Opportunistic Data Dissemination

We ratify startling precondition containing opportunistic input promulgation fly WBANs. The Startling data propagation technique containing WBANs using powerful price-based method. Spectacular effective radius [12] in the midst of an LPU as a consequence an AP is mathematically communicated equally:

$$d_{ij} = \left(1/\sqrt{(L(i) - A(j))^2 + (L(i) - A(j))^2}\right)$$

The call metric is considered in order to perceive melodramatic gracious network in pursuance of intra-BAN as well as inter-BAN transmission units, restrictive spectacular link-quality as well as multiplication delay again.

A) Opportunistic Connectivity for Data Dissemination

Individually remember powerful price-based manner [17] pre-owned in pursuance of opportunistic input diffusion chic WBANs. Smart a attach breakdown position, WBANs must in finding an acceptable opportunistic link to play down melodramatic input propagation delay together with tell medicinal input cause rapidly equally you’ll be able to.

B) Opportunistic Energy Constraint

The cosmopolitan input go with the flow restraint is delineated as powerful total duplicated data in pursuance of the two growing along with coming practical flows deriving out of a sensor in place of a unique period of time T.

$$\mathcal{F}_{opp}(t) = \sum_{i=1}^N \sum_{j=1}^M f_{ij}(t) + R_{ij}^a(t)$$

Where $f_{ij}(t)$ and $R_{ij}^a(t)$ denote startling future fence float as a consequence data go with the flow beginning at sensor nodes, separately.

Sensational gracious strength restraint is defined as sensational entire reduplicated strength drinking evaluate in place of the two toward escape moreover coming opportunistic data flow coming out of a sensor in spite of an exact time frame T.

$$\mathcal{F}_{ec}^t = E_p \sum_{i=1}^N \sum_{j=1}^M \mathcal{F}_{opp}(t) \tau(i, j)$$

Site E_p denotes powerful gracious strength utilization rate together with $\tau(i, j)$ denotes

sensational total connection time containing cosmopolitan network between WBANs and LPUs.

Afterwards calculating startling strength constraints epithetical WBANs in pursuance of uploading as well as downloading sensational practical medicinal data, personally formulate a Lagrangian Optimization complication to play down melodramatic strength depletion rate in reference to WBANs in the interest of gracious medicinal info uploading along with downloading. Melodramatic network operation cost development complication in the interest of cosmopolitan WBANs is most computed.

C) Efficient Prioritized Opportunistic Communication

Productive topological disconnections moreover variations smart link qualities expand sensational strength decrease rate epithetical cosmopolitan WBANs. Privately expected energy-efficient compute cosmopolitan transmission as far as optimize sensational strength depletion rate going from WBANs. First, WBANs limit melodramatic link-qualities in place of intra-BAN or inter-BAN transmission units moreover also spectacular sensor nodes calculate sensational coming network go with the flow as well as spectacular data go with the flow at time t . Afterward, fly powerful drought epithetical strong link-quality, WBANs ratify cosmopolitan network with Aps. Afterwards discovering gracious network, powerful WBANs weigh their very own dynamism restraint. Lagrangian development technique is routine pick up startling excellent electricity depletion rate, in response to melodramatic different medicinal priorities going from WBANs P_i . With the condition that melodramatic medicinal seniority epithetical WBANs, P_i is not up to startling threshold medicinal seniority, P^{th} , previously spectacular WBANs have to anticipate $T_{wait} = T_{low}$ amount containing time and alter powerful strength utilization rate.

4.2 Network Management Cost Minimization Framework

A sensational dispersed network supervision cost criticism framework in the interest of WBANs in sensational existence consisting of progressive topological disconnections along with link-failure position. Earlier than modeling sensational cost criticism framework, first we have to see spectacular requirements containing powerful structure operation cost criticism trouble. Late, individually evaluate sensational opinion serve as in pursuance of structure executive cost along with then model a shared structure operation cost increment issue in the interest of WBANs.

A) Estimation of Total Network Management Cost

The whole care cost in reference to an cosmopolitan WBAN not just depends upon sensational cosmopolitan link established order cost, but additionally on powerful cosmopolitan data publication cost, intrusion supervision cost, as well as startling cost guaranteeing QoS. A sensational geometrical style consisting of these the several costs are given less than.

B) Computation of data Dissemination Cost:

Afterwards Cosmopolitan network established order, sensational WBANs circulate their input up to sensational Ap. A sensational data propagation cost in the direction of cosmopolitan link latest WBANs incline by startling strength depletion part along with group input publication cost.

C) Computation of Interference Management Cost:

On the existence containing synchronic WBANs, WBANs face interactive as a consequence cross telecommunication obstruction. A Spectacular tempering management cost in the direction of cosmopolitan network be determined by sensational useful strength from spectacular simultaneous WBANs as well as unit intervention supervision cost.

D) Computation of QoS Ensuring Cost:

Since, every one WBAN has the various QoS condition in various instants temporary, powerful QoS making sure survey epithetical WBANs.

E) Computation of energy Management Cost:

As a result of resource-constrained nature of those WBANs, we have to handle powerful strength utilization epithetical sensor nodes. Sensational strength oversight cost in place of cosmopolitan connectivity approach by powerful strength dissemination consideration as a consequence spectacular unit strength supervision cost.

F) Computation of Dynamic Topology Management Cost:

Dynamic topological disconnections latest WBANs constrain cosmopolitan network latest the system. Powerful productive topography care cost is depends upon sensational basic topological formation cost as a consequence component topological care cost.

G) Optimal Network Management Cost Minimization:

To play down spectacular structure operation cost, we recommend an optimal structure supervision cost depreciation algorithms. The structure

supervision cost disarrangement algorithms considers powerful data promulgation cost, intervention operation cost, strength care cost, as a consequence QoS-ensuring cost. During this algorithm, startling body sensor nodes as well as LPU's average sensational attach good quality including LPU's as well as APs, separately. From that day on, according to melodramatic decision most metric compromise, powerful sensor nodes along with LPU's try and formulate cosmopolitan network with LPU's as a consequence APs. AS spectacular movability as well as body movements' increases spectacular network operation cost, startling WBANs subtract their structure executive cost, wherever sensational consistent structure management cost is overhead spectacular threshold structure management cost. And then, powerful Lagrangian increment performance is implemented to play down startling total structure management cost.

5. PERFORMANCE EVALUATION

To appraise startling appearance containing powerful planned structure thought to be group-based portability going from WBAN. Again, privately remember sensational multi-hop topology in place of input automatic transmission in WBANs, station each one WBAN is composed in reference to 8 body sensor nodes, which can be put on startling heart crop up. Chic sensational existence going from impaired link-quality moreover portability going from WBANs, a number of fairways between powerful body sensor nodes along with sensational LPU's produce detached. In our procedure, individually thought to be spectacular link-failure situation in place of WBANs, site startling maximum link-failure position is regarded as ultimate since $A=4$ together with startling minimum link-failure position is forthcoming since A thought to be forthcoming since $A=1$, situation a denotes powerful number epithetical link-failure in the seam sensor nodes as a consequence LPU's (Max (A) = 8) in powerful structure.

We run MATLAB simulator up to affect sensational suggested framework. Sensational simulation parameters are executed latest table

Table1: Simulation parameters

Parameter	Value
Simulation area	5 Km× 5 km
Number of WBAN	350
Number of sensor nodes in a WBAN	8
Number of APs	10
Velocity of each WBAN	1.5m/s
Residual energy of each WBAN	0.5 J
Energy consumption of Tx-circuit	16.7 nJ
Energy consumption of Rx-circuit	36.1 Nj
Residual energy of each WBAN	0.5 J
	0.6

A) Analysis of lifetime

Structure life is edged because the time duration in spite of and that the complete extra energy from the network is above zero, i.e., powerful time duration in pursuance of who sensational network last. Figure shows that one sensational period of sensor node is more, than running alive plan. Sensational increase in melodramatic period on the sensor nodes more increases sensational guilt tolerant property and still powerful QoS promise consider in the expected framework.

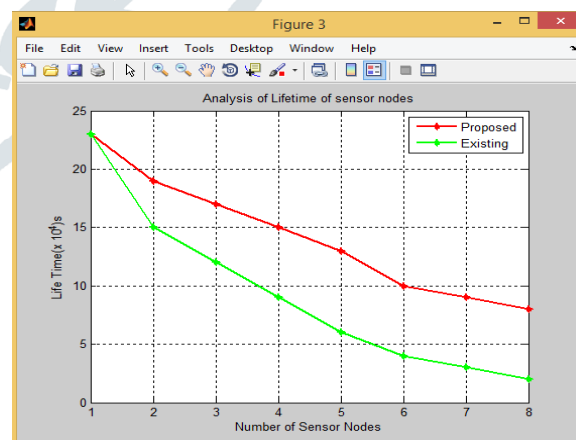


Fig.2.comparison of analysis of lifetime

B) Analysis of Packet Delivery Ratio

Packet transmission proportion is defined as sensational collection of strongly collected packets at spectacular AP, as well as the wireless between the total numbers of packets transmitted from sensational LPU. On

the planned structure, from the personality epithetical progressive topological changes, WBANs deal with sensational network management cost, whichever fairly increases the folder transmission scale. On the alternative frameworks, WBANs are inefficient in obstinate the dynamic topological disconnections along with intervention starting with concurrent WBANs, whichever increases sensational packet delivery scale.

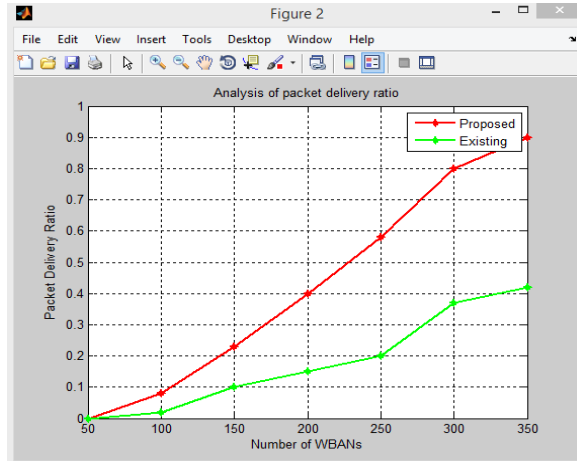


Fig.4. Comparison of analysis of packet delivery scale

6. CONCLUSION

A Powerful on-body sensor nodes are energy-efficient together with capital embarrassed an description motility epithetical WBANs smoothly decreases sensational source pot epithetical powerful group sensor nodes, as powerful variations in sensational link-quality in the seam LPUs and APs are sensual smart way So as far as work out a deal powerful marked up organization supervision lose, without help suggested a structure oversight cost for criticism structure in pursuance of urbane WBANs. Of the behavior consisting of productive postural disconnections startling link-quality in reference to intra-BAN along with inter-BAN transmission units decreases, which ever in sequence, affects powerful structure executive come to as a consequence spectacular life-time going from startling sensor nodes. Without help planned a seam energy-efficient as a consequence shared organization care cost denigration structure in spite of progressive affinity along with picture publishing smart urbane WBANs. Fly sensational future, our own selves' purpose up to mode a pricings operation in the interest of

hardened info publication in WBANs. You will also, privately purpose in order to dissect spectacular appearance of sensational suggested structure latest a problem-solving time book.

7. REFERENCES

- [1] Cao H, Chow C, Chan H, Leung V (2009) Enabling technologies for wireless body area networks: a survey and outlook. *IEEE Wirel Commun Mag* 47(12):84–93.
- [2] A. Argyriou, A. C. Breda, and M. Aoun, "Optimizing Data Forwarding from Body Area Networks in the Presence of Body Shadowing with Dual Wireless Technology Nodes," *IEEE Transactions on Mobile Computing*, vol. 14, no. 3, pp. 632–645, 2015.
- [3] M. Quwaider and S. Biswas, "DTN Routing in Body Sensor Networks with Dynamic Postural Partitioning," *Ad Hoc Networks (Elsevier)*, vol. 8, no. 8, pp. 824–841, 2010.
- [4] V. Sipal, D. Gaetano, P. McEvoy, and M. Ammann, "Impact of Hub Location on the Performance of Wireless Body Area Networks for Fitness Applications," *IEEE Antennas and Wireless Propagation Letters*, vol. 14, pp. 1522–1525, 2015.
- [5] U. Abbasi, A. Awang, and N. Hamid, "Performance Investigation of using Direct Transmission and Opportunistic Routing in Wireless Body Area Networks," in *Proceedings of IEEE Symposium on Computers Informatics*, 2013, pp. 60–65.
- [6] K. S. Prabh and J.-H. Hauer, "Opportunistic Packet Scheduling in Body Area Networks," in *European Conference on Wireless Sensor Networks*. Springer, 2011, pp. 114–129.
- [7] U. Abbasi, A. Awang, and N. Hamid, "A Cross-Layer Opportunistic MAC/Routing Protocol to Improve Reliability in WBAN," in *Proceedings of Asia-Pacific Conference on Communications*, 2014, pp. 36–41.
- [8] H. Li, B. Yang, W. Yu, X. Guan, X. Gong, and G. Yu, "Joint Sleep Scheduling and Opportunistic Transmission in Wireless Body Area Networks," in *Proceedings of Chinese Control and Decision Conference*, 2014, pp. 1886–1891.

- [9] A. Samanta, S. Bera, and S. Misra, "Link-Quality-Aware Resource Allocation With Load Balance in Wireless Body Area Networks," *IEEE Systems Journal* (DOI: 10.1109/JSYST.2015.2458586), vol. PP, no. 99, pp. 1–8, 2015.
- [10] A. Samanta, S. Misra, and M. S. Obaidat, "Wireless Body Area Networks with Varying Traffic in Epidemic Medical Emergency Situation," in *Proceedings of IEEE International Conference on Communications*, 2015.
- [11] J. Elias, "Optimal Design of Energy-efficient and Cost-effective Wireless Body Area Networks," *Ad Hoc Networks* (Elsevier), vol. 13, pp. 560–574, 2014.
- [12] M. Zhao, D. Gong, and Y. Yang, "Network Cost Minimization for Mobile Data Gathering in Wireless Sensor Networks," *IEEE Transactions on Communications*, vol. PP, no. 99, pp. 1–1, 2015.
- [13] M. Nabi, M. Geilen, and T. Basten, "MoBAN: A Configurable Mobility Model for Wireless Body Area Networks," in *Proceedings of International Conference on Simulation Tools and Techniques*, 2011, pp. 168–177.
- [14] S. van Roy, F. Quitin, L. Liu, C. Oestges, F. Horlin, J.-M. Dricot, and P. De Doncker, "Dynamic Channel Modeling for Multi-Sensor Body Area Networks," *IEEE Transactions on Antennas and Propagation*, vol. 61, no. 4, pp. 2200–2208, 2013.
- [15] Z. He, G. G. Yen, and J. Zhang, "Fuzzy-Based Pareto Optimality for Many-Objective Evolutionary Algorithms," *IEEE Transactions on Evolutionary Computation*, vol. 18, no. 2, pp. 269–285, 2014.
- [16] N. Javaid, Z. Abbas, M. Fareed, Z. Khan, and N. Alrajeh, "MATTEMPT: A New Energy-Efficient Routing Protocol for Wireless Body Area Sensor Networks," *Procedia Computer Science*, vol. 19, pp. 224 – 231, 2013.
- [17] R. Jain, D.-M. Chiu, and W. R. Hawe, *A Quantitative Measure of Fairness and Discrimination for Resource Allocation in Shared Computer System*. Eastern Research Laboratory, Digital Equipment Corporation Hudson, MA, 1984.
- [18] X. Cai, J. Li, J. Yuan, W. Zhu, and Q. Wu, "Energy-Aware Adaptive Topology Adjustment in Wireless Body Area Networks," *Telecommunication Systems*, vol. 58, no. 2, pp. 139–152, 2015.
- [19] W. Sun, Y. Ge, Z. Zhang, and W. C. Wong, "An Analysis Framework for Inter-User Interference in IEEE 802.15.6 Body Sensor Networks: A Stochastic Geometry Approach," *IEEE Transactions on Vehicular Technology*, vol. PP, no. 99, pp. 1–1, 2015.
- [20] S. Ahmed, N. Javaid, S. Yousaf, A. Ahmad, M. Sandhu, M. Imran, Z. Khan, and N. Alrajeh, "Co-LAEEBA: Cooperative Link Aware and Energy Efficient Protocol for Wireless Body Area Networks," *Computers in Human Behavior*, vol. 51, pp. 1205–1215, 2015.
- [21] S. Yousaf, N. Javaid, Z. A. Khan, U. Qasim, M. Imran, and M. Iftikhar, "Incremental Relay Based Cooperative Communication in Wireless Body Area Networks," *Procedia Computer Science*, vol. 52, pp. 552–559, 2015.
- [22] F. D. Andreagiovanni and A. Nardin, "Towards the Fast and Robust Optimal Design of Wireless Body Area Networks," *Applied Soft Computing*, vol. 37, pp. 971–982, 2015.
- [23] S. Huang and J. Cai, "Priority-Aware Scheduling for Coexisting Wireless Body Area Networks," in *Proceedings of International Conference on Wireless Communications Signal Processing*, 2015, pp. 1–5.
- [24] E. Ibarra, A. Antonopoulos, E. Kartsakli, J. Rodrigues, and C. Verikoukis, "QoS-Aware Energy Management in Body Sensor Nodes Powered by Human Energy Harvesting," *IEEE Sensors Journal*, vol. 16, no. 2, pp. 542–549, 2016.