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# M3WSN Research Project Summary


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## Abstract


The Mobile Multi-Media Wireless Sensor Network (M3WSN) project focused on the dissemination of multimedia packet in mobile wireless ad-hoc network environments. We designed, implemented, and validated a multi-tier network architecture for mobile multimedia sensing, a novel opportunistic routing protocol, and a QoE-aware FEC mechanism for intruder detection in multi-tier multimedia wireless sensor networks.


## Main Contributions

- Novel opportunistic routing protocol[1]
- Simulation framework for video transmission[2]
- Quality of Experience (QoE)-aware FEC[4]
- Diseminating multimedia data using social networks[3]
- Hierarchical Multi-hop Multimedia Routing Protocol[5]
- Multi-tier architecture for intrusion detection[4]

## Topology and Link Quality-aware Geographical Opportunistic Routing Protocol

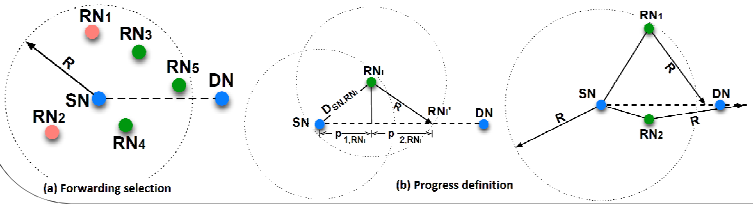
- Opportunistic routing (OR) makes use of the wireless broadcast nature.
- Existing OR protocols choose the next-hop forwarder based on a predefined candidate list, which is calculated using single metrics.
- TLG – *Topology and Link Quality-aware Geographical* opportunistic routing - uses multiple network metrics to implement the coordination mechanism of OR.
- TLG outperforms other protocols in terms of both QoS and QoE metrics.
  - Forwarding decision depends on information in the received packet
  - Nodes apply *Dynamic Forwarding Delay*(DFD) using multiple metrics

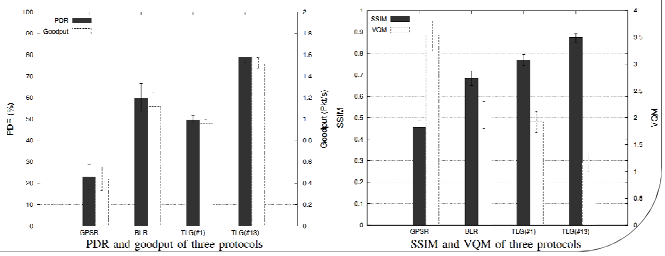
$$\mathrm{DFD} = \mathrm{DFD}_{\mathrm{Max}} \times (\alpha \times \mathrm{linkQuality} + \beta \times \mathrm{progress} + \gamma \times \mathrm{energy})$$

$$\mathrm{linkQuality} = \begin{cases} 0 & \text{if } LQE_t > LQE_{Good} \\ \dfrac{LQE_{Max} - LQE_t}{LQE_{Max}} & \text{if } LQE_{Bad} < LQE_t < LQE_{Good} \\ 1 & \text{if } LQE_t < LQE_{Bad} \end{cases}$$

$$energy = \begin{cases} E_0 - RemainingEnergy & \text{if } RE > E_{Min} \\ 1 & \text{if } RE < E_{Min} \end{cases}$$

$$progress = \begin{cases} \dfrac{2R - P_{RN_i}}{2R} & \text{if } D_{RN_i,\,DN} > R \\ 0 & \text{if } D_{RN_i,\,DN} < R \end{cases}$$




PDR and goodput of three protocols

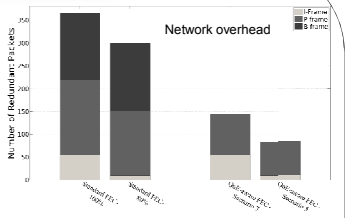
SSIM and VQM of three protocols

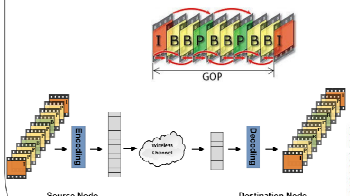
## QoE-aware FEC Mechanism for Intrusion Detection in Multi-tier Multimedia WSNs

- Forward Error Correction (FEC) is regarded as an efficient solution to improve video quality in WMSNs.
- A QoE-aware FEC mechanism for WMSNs, creates redundant packets based on the impact of the video frame (I/P/B frames).
- Frames I/P/B with full/partial/null redundancy.
- The proposal achieved similar video quality level compared with standard FEC, while reducing the number of transmission of redundant packets.

| Scenario # | First 60% of P-frames redundant | Last 40% of P-frames redundant | Network Overhead (Packet #) | Scenario # | First 50% of P-frames redundant | Last 50% of P-frames redundant | Network Overhead (Packet #) |
|---|---|---|---|---|---|---|---|
| 1 | 80% | 0% | 96 | 5 | 80% | 0% | 84 |
| 2 | 80% | 40% | 152 | 6 | 80% | 40% | 152 |
| 3 | 100% | 0% | 159 | 7 | 100% | 0% | 145 |
| 4 | 100% | 50% | 215 | 8 | 100% | 50% | 213 |

Scenario definition

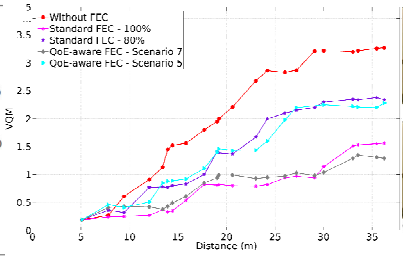


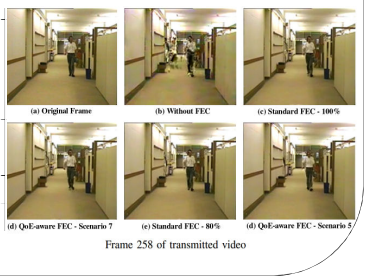




QoE aware FEC Mechanism

**Algorithm 1** QoE-aware FEC Mechanism

```
Incoming Frame
Let r = redundancy
Let s = GOP size
Let p = frame position inside a GOP
Let n = number of packets after frame fragmentation
if FrameType = I then
    k ← ComputeRedundancy (n, r); //using RS coding, RS(k, n)
    SendWithFEC(k, n)
end if
if FrameType = P and p < s/2 then
    k ← ComputeRedundancy (n, r); //using RS coding, RS(k, n)
    SendWithFEC(k, n)
end if
if FrameType = P and p > s/2 then
    SendWithoutFEC(n)
end if
if FrameType = B then
    SendWithoutFEC(n)
end if
```




Frame 258 of transmitted video

## Publications


1) Z. Zhao, D. Rosario, T. Braun, E. Cerqueira, H. Xu, L. Huang: Topology and Link Quality-aware Geographical Opportunistic Routing in Wireless Ad-hoc Networks, The 9th International Wireless Communications & Mobile Computing Conference (IWCMC), Cagliari, Italy, July 1 - 5, 2013.
2) D. Rosario, Z. Zhao, C. Silva, E. Cerqueira, T. Braun: An OMNeT++ Framework to Evaluate Video Transmission in Mobile Wireless Multimedia Sensor Networks, 6th International Workshop on OMNET++, Cannes, March 5, 2013.
3) D. Rosario, P. Lima, K. Machado, E. Cerqueira, Z. Zhao, T. Braun: Demo Abstract: Disseminating WMSN Data by Using Social Network and Web, 10th European Conference on Wireless Sensor Networks (EWSN), Ghent, Belgium, February 13, 2013.
4) Z. Zhao, T. Braun, D. Rosario, E. Cerqueira, R. Immich, M. Curado: QoE-aware FEC Mechanism for Intrusion Detection in Multi-tier Wireless Multimedia Sensor Networks, 1st International Workshop on Wireless Multimedia Sensor Networks (WiMob'12 WS-WMSN), Spain, October 8, 2012.
5) D. Rosario, R. Costa, H. Paraense, K. Machado, E. Cerqueira, T. Braun, Z. Zhao: A Hierarchical Multi-hop Multimedia Routing Protocol for Wireless Multimedia Sensor Networks, Network Protocols and Algorithms - Special Issue on 2nd IEEE Smart Communication Protocols and Algorithms, Vol. 4, Nr. 4, December, 2012, pp. 44-64, Journal of Macrothink Institute.