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Outline

- Introduction
- M3WSN framework
- Protocol evaluation
- Conclusions
Multimedia Wireless Sensor Networks (MWSNs)

- The multimedia content has the potential to enhance the level of collected information, compared with scalar data.

- MWSNs promise a wide range of applications, which require audio and video transmission:
  - Traffic collision avoidance
  - Environment monitoring
  - Video surveillance
  - Smart city application
Mobile Multimedia Wireless Sensor Networks

> Mobile communications are enhancing MWSN scenarios with mobility support for objects and sensor nodes

> The objects that to be monitored (e.g., car, people, or animals) are naturally mobile

> Mobile sensor equipped with sensor camera could be used to explore and sense the hazardous area where rescuers can’t reach easily or faster
Motivations I

- The development and evaluation of new protocols for WMSNs are usually performed by network simulator
- Solutions involving multimedia video transmission must be evaluated from the end-user’s perspective
- Video flows have different characteristics, group of picture sizes, and coding mechanisms
- Multimedia transmissions/evaluations require video-related data:
  - Frame type
  - Delay and jitter requirements
  - Decoding errors
  - Inter and intra-frame dependency
Motivations II

- Mobility traces enable the understanding of how the network protocols and algorithms behave under different mobile cases.

- Mobile scenarios enable complex mobility simulations, as expected in many smart city applications.

- OMNeT++ is a standard and general purpose network simulator employed to study protocols in wired and wireless networks.

- The existing OMNeT++ frameworks for WMSNs do not provide a large set of mobility models.

- No support of multimedia video transmission and evaluation.
## Related Works

<table>
<thead>
<tr>
<th>Pros</th>
<th>Cons</th>
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<tbody>
<tr>
<td><strong>Castalia</strong></td>
<td>• Does not provide video transmission, control and evaluation.</td>
</tr>
<tr>
<td>• Advanced wireless channel, radio, and power consumption models.</td>
<td>• Includes basic mobility model, e.g., linear mobility.</td>
</tr>
<tr>
<td>• Well-defined architecture</td>
<td>• Does not support moving object.</td>
</tr>
<tr>
<td><strong>WiSE-Mnet</strong></td>
<td>• Does not provide video transmission, control and evaluation.</td>
</tr>
<tr>
<td>• Proposes the use of moving objects, e.g. intruder</td>
<td>• Does not support node mobility with complex traces</td>
</tr>
<tr>
<td>• Object detection.</td>
<td></td>
</tr>
<tr>
<td><strong>WVSN</strong></td>
<td>• Does not provide video transmission, mobility traces and moving object.</td>
</tr>
<tr>
<td>• defines the sensing range of camera nodes by a Field of View (FoV)</td>
<td></td>
</tr>
<tr>
<td>• Introduces the notion of cover-sets and application criticality.</td>
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M3WSN Framework

> Mobile Multi-Media Wireless Sensor Networks (M3WSN) OMNeT++ Simulation Framework
> Relies on Castalia architecture
> Integration of functionalities of:
  > WiSE-Mnet model: moving objects and object detection
  > WVSN model: FoV, cover set, and application criticality
> M3WSN provides:
  — Implementation of new functions to provide mobile multimedia management
  — Delivering, controlling, and evaluating real video sequences
  — Scenarios consist of fixed and mobile nodes, as well as moving objects
  — Measurement of the impact and benefits of novel video-aware algorithms and protocols for fixed and mobile MWSNs
M3WSN Architecture
Multimedia Management

> M3WSN incorporates Evalvid, which provides video-related information:
  > Received/lost frame and their types
  > Delay and jitter
  > Decoding errors
  > Inter and intra-frame dependency

> Video-related information enables the creation of new assessment and optimization solutions for static and mobile MWSN applications

> M3WSN enables the definition of energy consumption values for retrieving each frame
The destination node creates a receiver trace file for every received video,

<table>
<thead>
<tr>
<th>time stamp [s]</th>
<th>packet id</th>
<th>payload size</th>
</tr>
</thead>
<tbody>
<tr>
<td>1029710404.014760</td>
<td>id 48946</td>
<td>udp 24</td>
</tr>
<tr>
<td>1029710404.048304</td>
<td>id 48947</td>
<td>udp 1024</td>
</tr>
<tr>
<td>1029710404.048376</td>
<td>id 48948</td>
<td>udp 1024</td>
</tr>
</tbody>
</table>

...
Quality of Experience Support

> Multimedia transmission should be evaluated from the end user’s perspective

> Quality-of-Experience evaluation approaches:
  > Objective
    > Peak Signal to Noise Ratio (PSNR)
    > Structural Similarity (SSIM)
    > Video Quality Metric (VQM)
  > Subjective
    > Mean Option Score (MOS)
Mobility Support

> M3WSN relies on BonnMotion framework (at the mobility manager) to fully various mobility models

> BonnMotion provides several mobility models
  > Random Walk, Random Waypoint, etc

> Enables users to configure the energy consumption for a node when it is moving within a certain area
Protocol Evaluation

> Experiment Scenario

> Intrusion detection with multi-tier MWSNs
> As soon as the low-tier scalar sensors detect the intruder, it wakes up/trigger the high-tier camera sensor to send the video flows
> Message transmission among camera nodes follows a QoE-aware FEC (Forward Error Correction mechanism)
  > QoE-aware FEC (Reed-Solomon coding) achieves robust video transmission by sending redundant packets according to their importance
  > In case of packet loss, the original frames can be recovered from the redundant packets
Scenario Parameters & Metrics

> Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
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<tbody>
<tr>
<td>Field Size</td>
<td>80x80</td>
</tr>
<tr>
<td>Location of Base Station</td>
<td>40, 0</td>
</tr>
<tr>
<td>Initial location of intruder</td>
<td>0, 0</td>
</tr>
<tr>
<td>Intruder movement type</td>
<td>Random mobility</td>
</tr>
<tr>
<td>Intruder velocity</td>
<td>1.5</td>
</tr>
<tr>
<td>Total number of Nodes</td>
<td>100</td>
</tr>
<tr>
<td>Number of nodes at high-tier</td>
<td>25</td>
</tr>
<tr>
<td>High-tier deployment</td>
<td>Grid</td>
</tr>
<tr>
<td>Low-tier deployment</td>
<td>Uniform</td>
</tr>
<tr>
<td>Transmission Power</td>
<td>-15 dbm</td>
</tr>
<tr>
<td>Path loss model</td>
<td>Lognormal shadowing model</td>
</tr>
<tr>
<td>Radio model</td>
<td>CC2420</td>
</tr>
<tr>
<td>Video sequence</td>
<td>Hall</td>
</tr>
<tr>
<td>Video Encoding</td>
<td>H.264</td>
</tr>
<tr>
<td>Video Format</td>
<td>QCIF (176 x 144)</td>
</tr>
<tr>
<td>Frame Rate</td>
<td>26 fps</td>
</tr>
</tbody>
</table>

> Metrics

> Objective QoE evaluation: SSIM and VQM
> Subjective evaluation: network overhead and transmitted frame
Objective Results: SSIM

![Graph showing SSIM results for different FEC strategies](image-url)
Objective Results: VQM
Subjective Results: Overhead
Subjective Results: Transmitted Video Frame

(a) Original Frame
(b) no-FEC
(c) QoE-aware FEC
(d) Simple FEC
Conclusion

> Mobile Multi-Media Wirless Sensor Networks (M3WSN) OMNeT++ Simulation Framework
  > Supports real video sequence transmission
  > Provides key video-related information, which can be used for creating new assessment and optimization solutions for MWSNs
  > Provides QoE evaluation, which is only possible through the transmission of real video sequence
  > Supports several mobility traces to enable the understanding of how protocols/algorithms behave under different mobile situations

> [http://cds.unibe.ch/research/M3WSN/](http://cds.unibe.ch/research/M3WSN/)
Thanks for Your Attention.

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> http://cds.unibe.ch