GERCOM
Research Group on Computer Networks and Multimedia Communication
UFPA - Brazil

UNIVERSITÄT BERN

6th International Workshop on OMNeT++

An OMNeT++ Framework to Evaluate Video Transmission in Mobile Wireless Multimedia Sensor Networks

Denis Rosário, Zhongliang Zhao, Claudio Silva, Eduardo Cerqueira, and Torsten Braun

rosario@iam.unibe.ch, cds.unibe.ch

Outline

- Introduction
- Related Works
- M3WSN framework
- Evaluation
- Conclusion

UNIVERSITÄT BERN
GERCOM
Research Group on Computer Networks and Multimedia Communication
UFPA - Brazil

Introduction to WMSN

- The multimedia content has the potential to enhance the level of collected information, compared with scalar data.
- WMSNs promise a wide scope of applications, which require audio and video information:
  - Traffic avoidance;
  - Environmental monitoring;
  - Video surveillance;
  - Smart cities.

Mobile WMSNs

- Mobile communications are enhancing WMSN scenarios with mobility support for objects, sensor nodes or both.
- The objects that have to be monitored (e.g., cars, people or animals) are naturally mobile.
- Mobile sensor equipped with sensor camera could be used to explore and sense the hazardous areas where rescuers cannot reach easily or faster.

Motivation I

- The development and evaluation of new algorithms, protocols and applications for WMSNs are usually supported by means of simulator.
- An event-driven simulation enables the evaluation of different parameters before the real deployment
  - reducing cost, time and human resources.

Motivation II

- Solutions involving multimedia transmission must evaluate the video content from the user's perspective.
- Video flows have different characteristics, genres, group of pictures lengths, and coding techniques.
- The multimedia transmissions/evaluations require video-related information:
  - frame type and received/lost;
  - delay, and jitter;
  - decoding errors; and
  - inter and intra-frame dependency.

Motivation III

- Mobility traces enable the understanding of how the network protocols and algorithms behave under different mobile situations.
- This enables more complex mobile simulations, as expected for many smart cities applications:
  - car-based video surveillance.

Motivation IV

- OMNeT++ is a standard and general-purpose simulator employed to study protocols in wired and wireless networks.
- The existing OMNeT++ frameworks for WMSNs do not support the video-aware transmission, and do not provide a large set of mobility models.

M3WSN framework

- We propose a Mobile MultiMedia Wireless Sensor Network OMNeT++ framework (M3WSN)
- M3WSN framework implements full support for:
  - delivering, controlling, and evaluating real video sequences.
  - scenarios composed of fixed and mobile nodes, as well as moving object.

Related works

Related works

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

UNIVERSITÄT BERN
GERCOM
Research Group on Computer Networks and Multimedia Communication
UFPA - Brazil

Mobile MultiMedia Wireless Sensor Network OMNeT++ framework (M3WSN)

GERCOM
Research Group on Computer Networks and Multimedia Communication
UFPA - Brazil

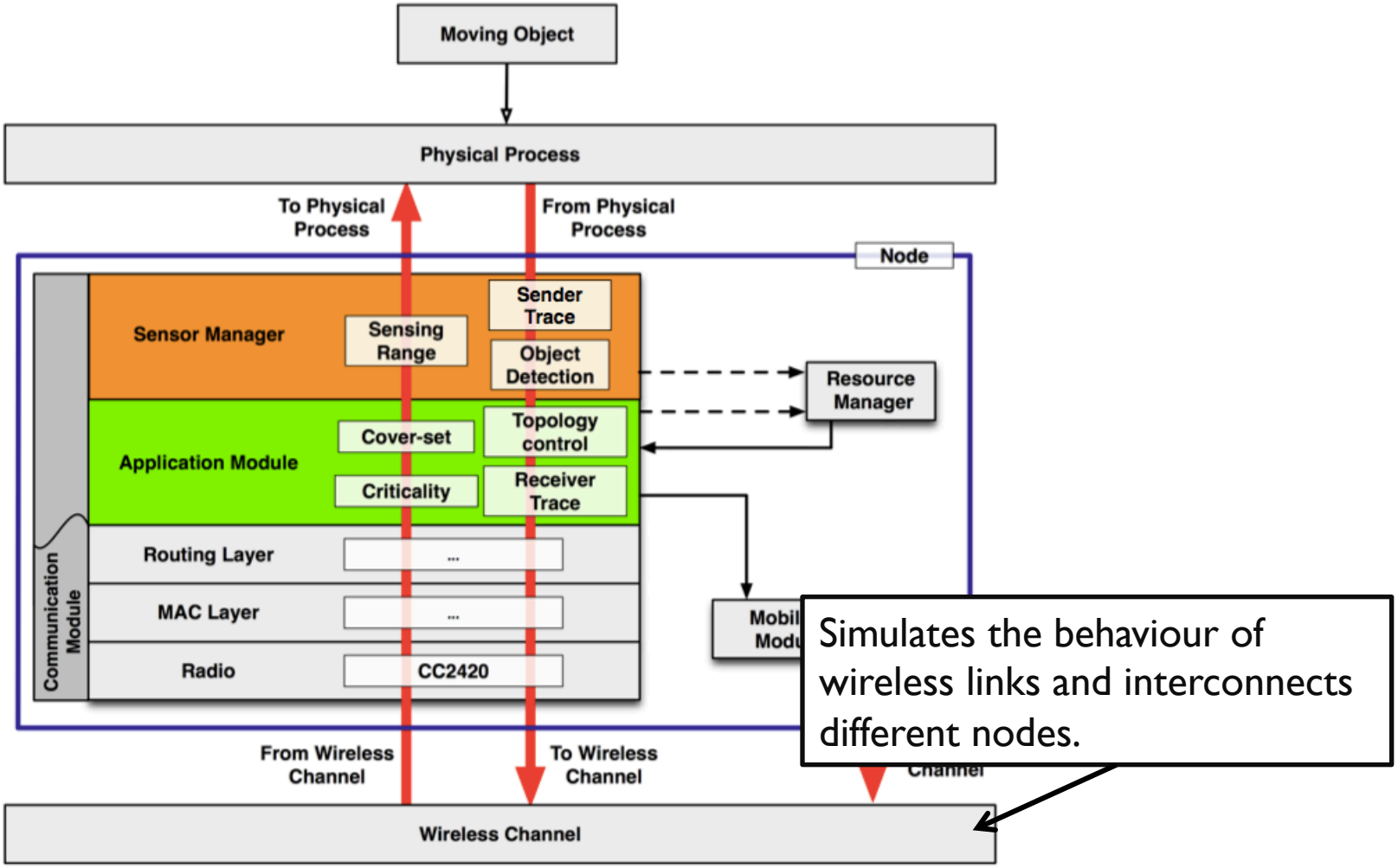
UNIVERSITÄT BERN

M3WSN framework

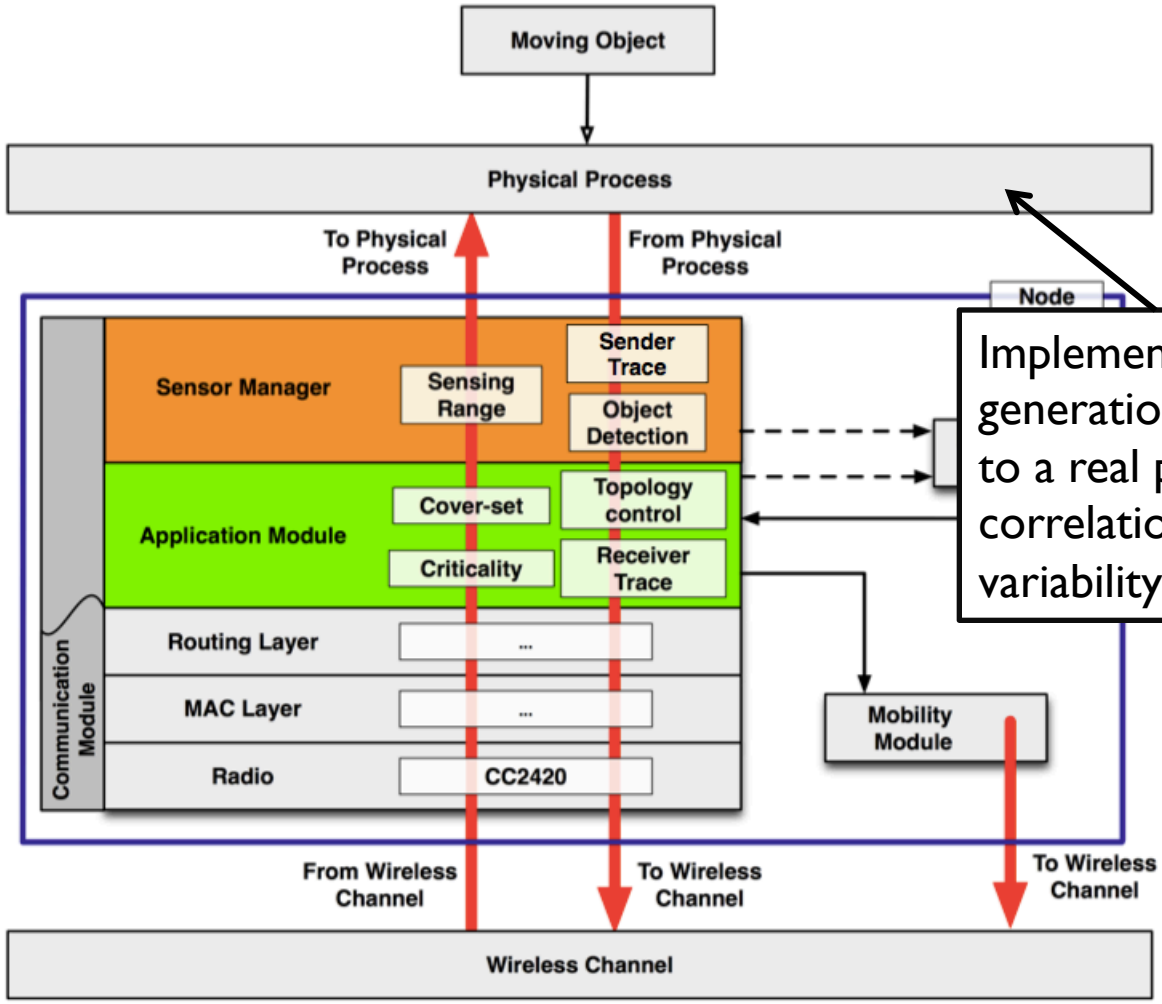
- Relies on Castalia architecture.
- Integrates functionalities of:
  - WiSE-Mnet: moving objects, and object detection.
  - WVSN model: FoV, cover-set and application criticality.
- Implements new functionalities to provide mobile multimedia-aware management.
- Measures the impact and benefits of novel video-aware algorithms and protocols for fixed/ mobile WMSN.

UNIVERSITÄT BERN
GERCOM
Research Group on Computer Networks and Multimedia Communication
UFPA - Brazil

M3WSN Framework Architecture



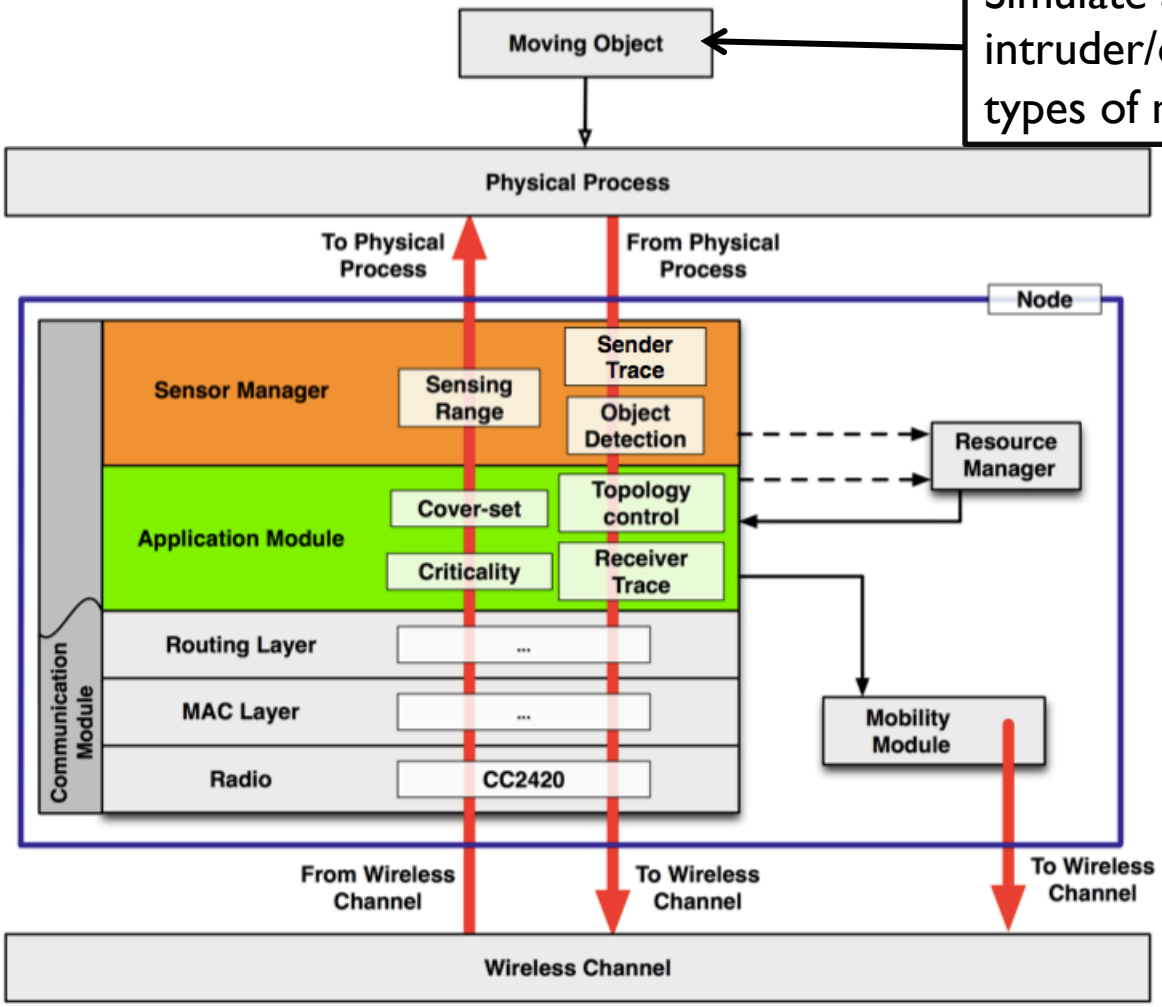
M3WSN Framework Architecture



Implements a sensed-data generation, which correspond to a real process with spatial correlation of data and variability over time.

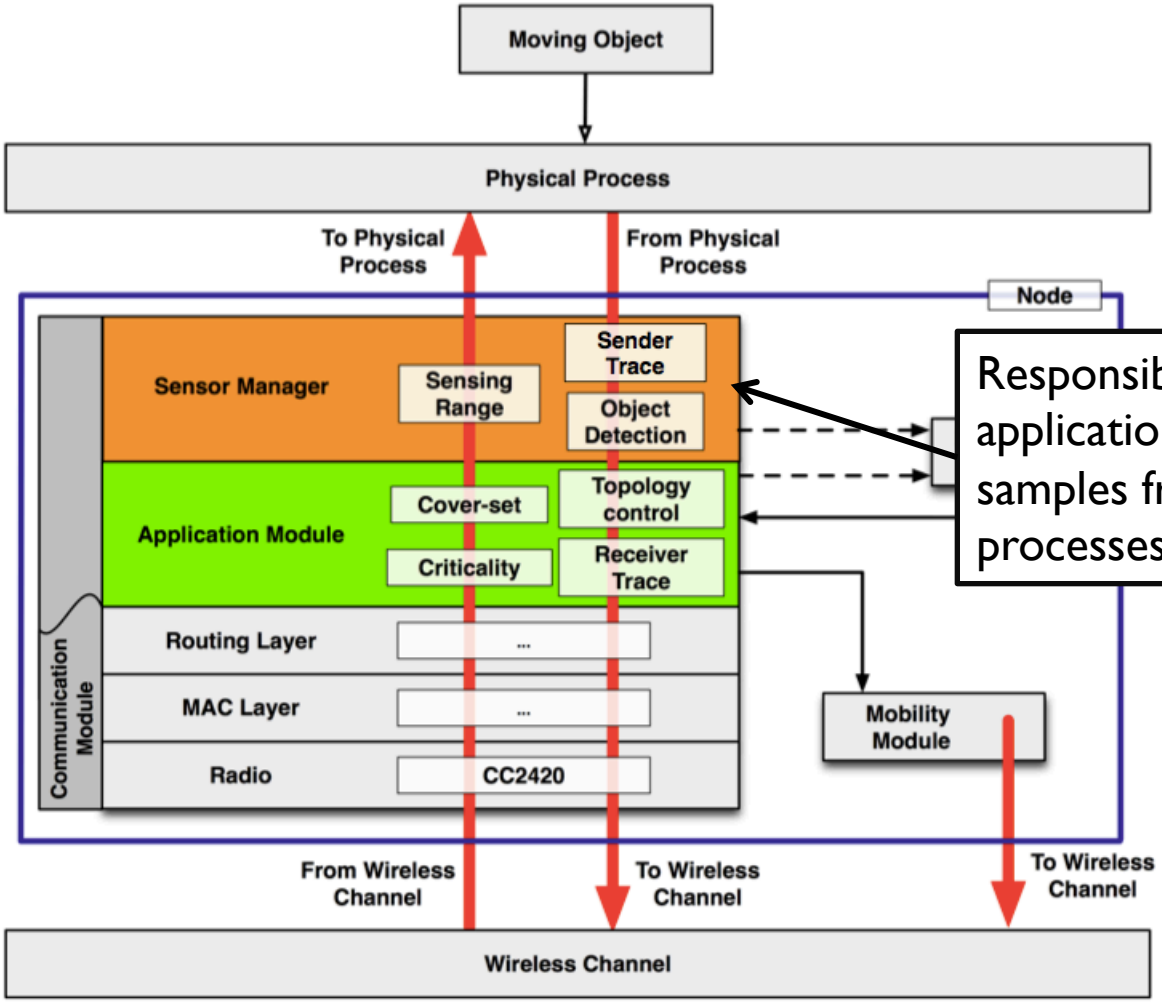
M3WSN Framework Architecture

Simulate a realistic mobile intruder/object with different types of mobility traces.



GERCOM
Research Group on Computer Networks and Multimedia Communication
UFPA - Brazil

M3WSN Framework Architecture

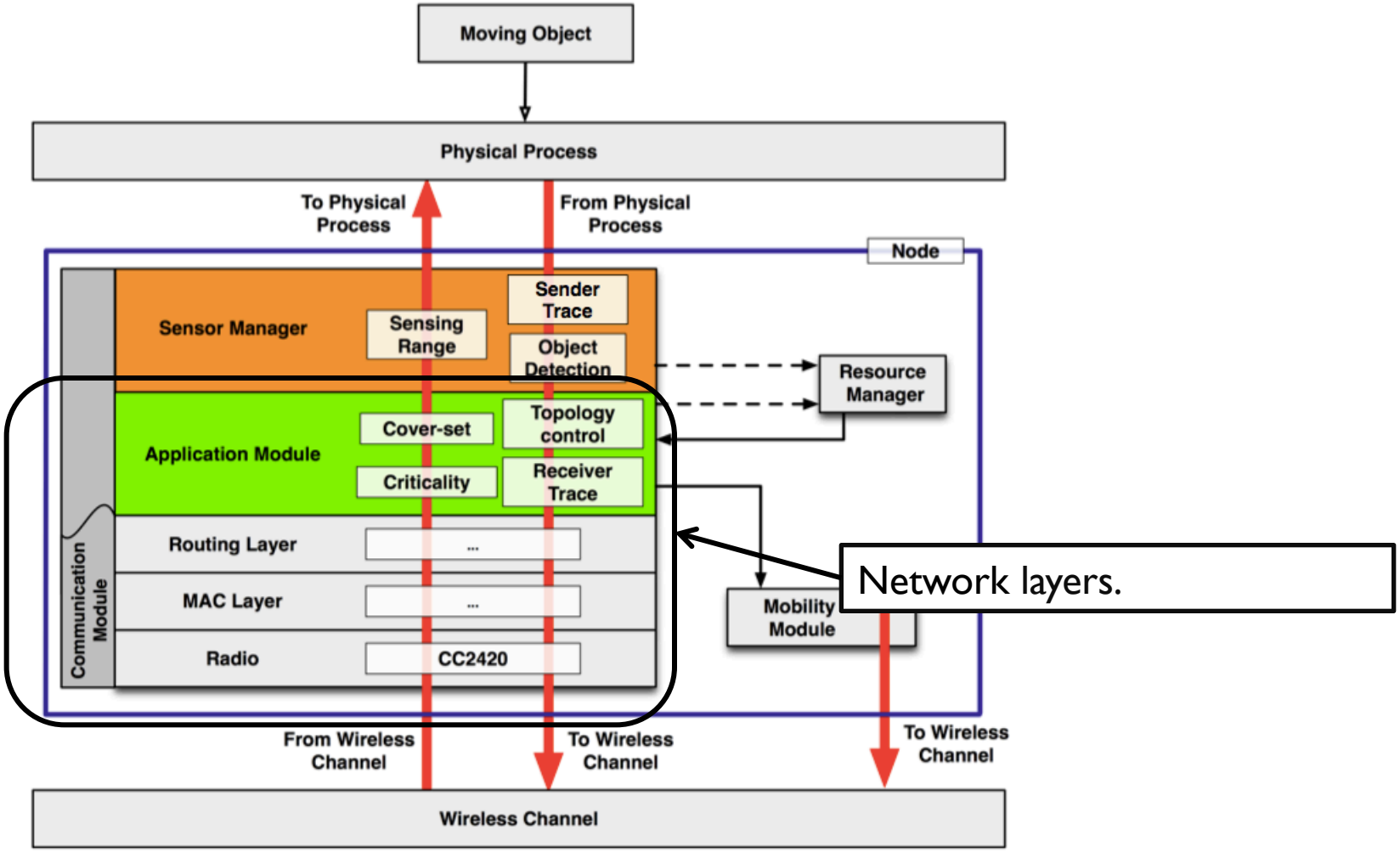


Responsible for providing the application module with new samples from physical processes.

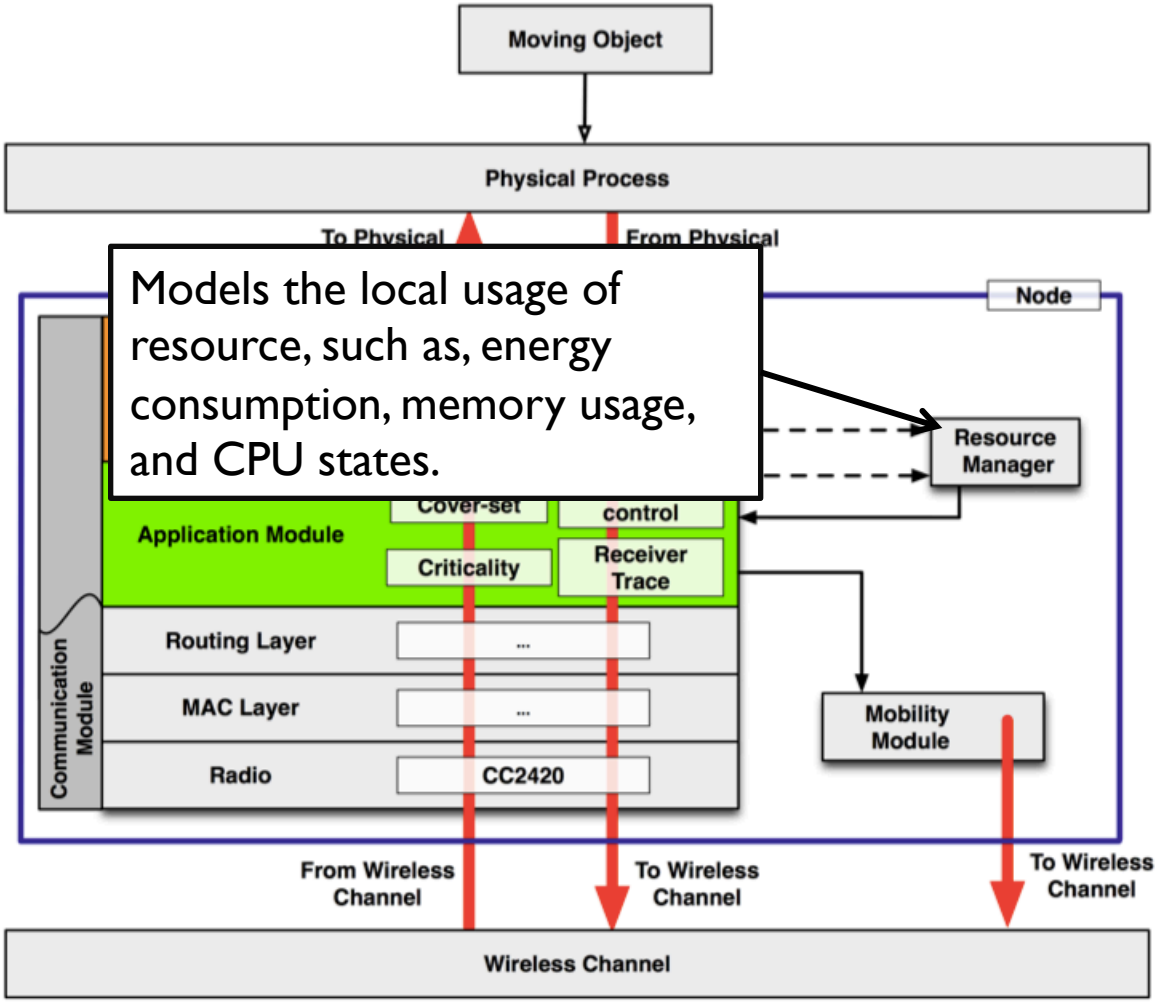
UNIVERSITÄT BERN

GERCOM
Research Group on Computer Networks and Multimedia Communication
UFPA - Brazil

M3WSN Framework Architecture



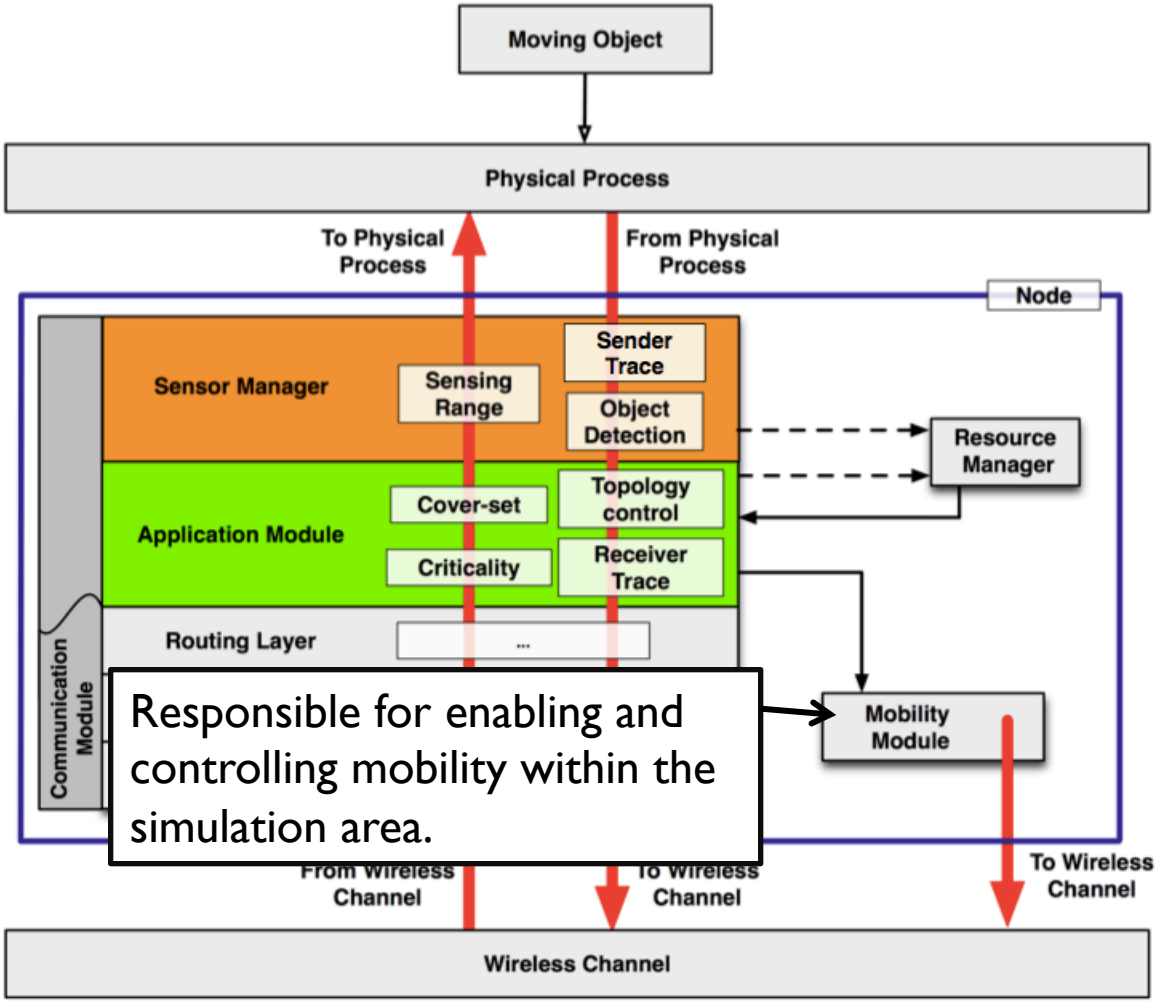
M3WSN Framework Architecture



Models the local usage of resource, such as, energy consumption, memory usage, and CPU states.

GERCOM
Research Group on Computer Networks and Multimedia Communication
UFPA - Brazil

M3WSN Framework Architecture



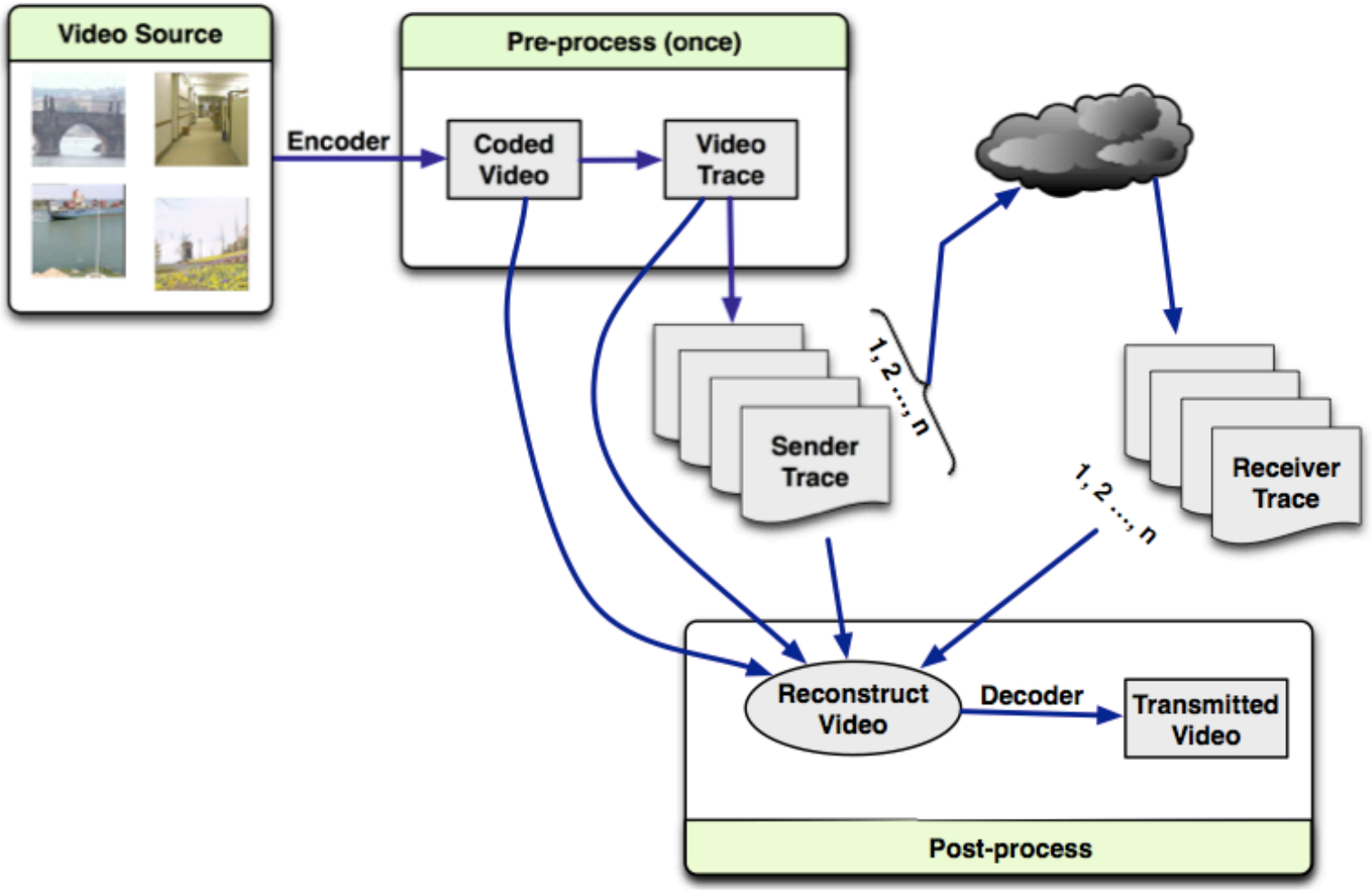
Responsible for enabling and controlling mobility within the simulation area.

GERCOM
Research Group on Computer Networks and Multimedia Communication
UFPA - Brazil

Multimedia management I

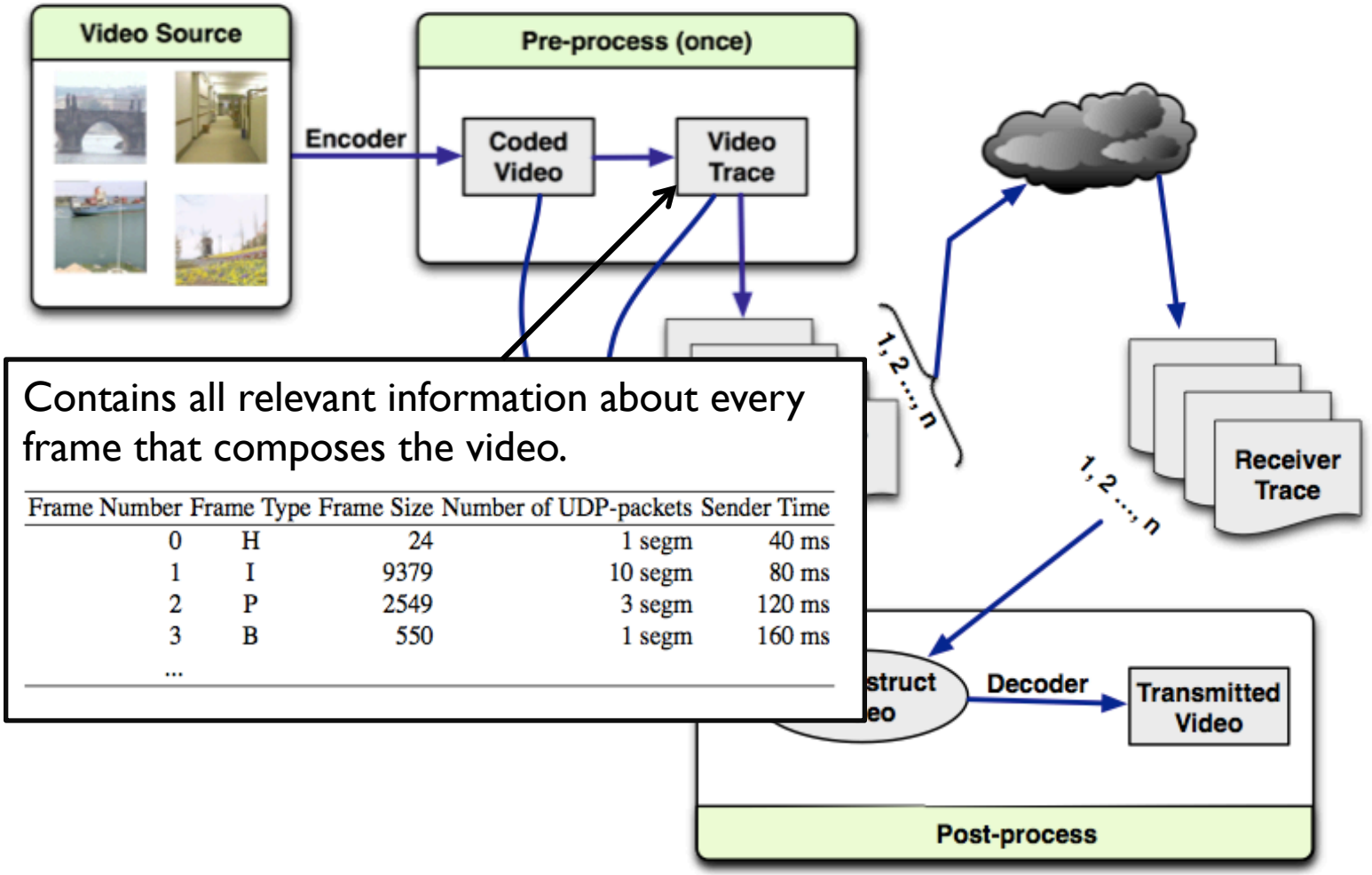
- We ported Evalvid to M3WSN.
- Evalvid provides video-related information:
  - Frame type, received/lost;
  - Delay, and jitter;
  - decoding errors;
  - Inter and intra-frame dependency
- This video-related information enables the creation of new assessment and optimization solutions for fixed and mobile WMSN scenarios.
- M3WSN framework enables the definition of energy consumption values for retrieving each frame.

Multimedia management II



GERCOM
Research Group on Computer Networks and Multimedia Communication
UFPA - Brazil

Multimedia management II

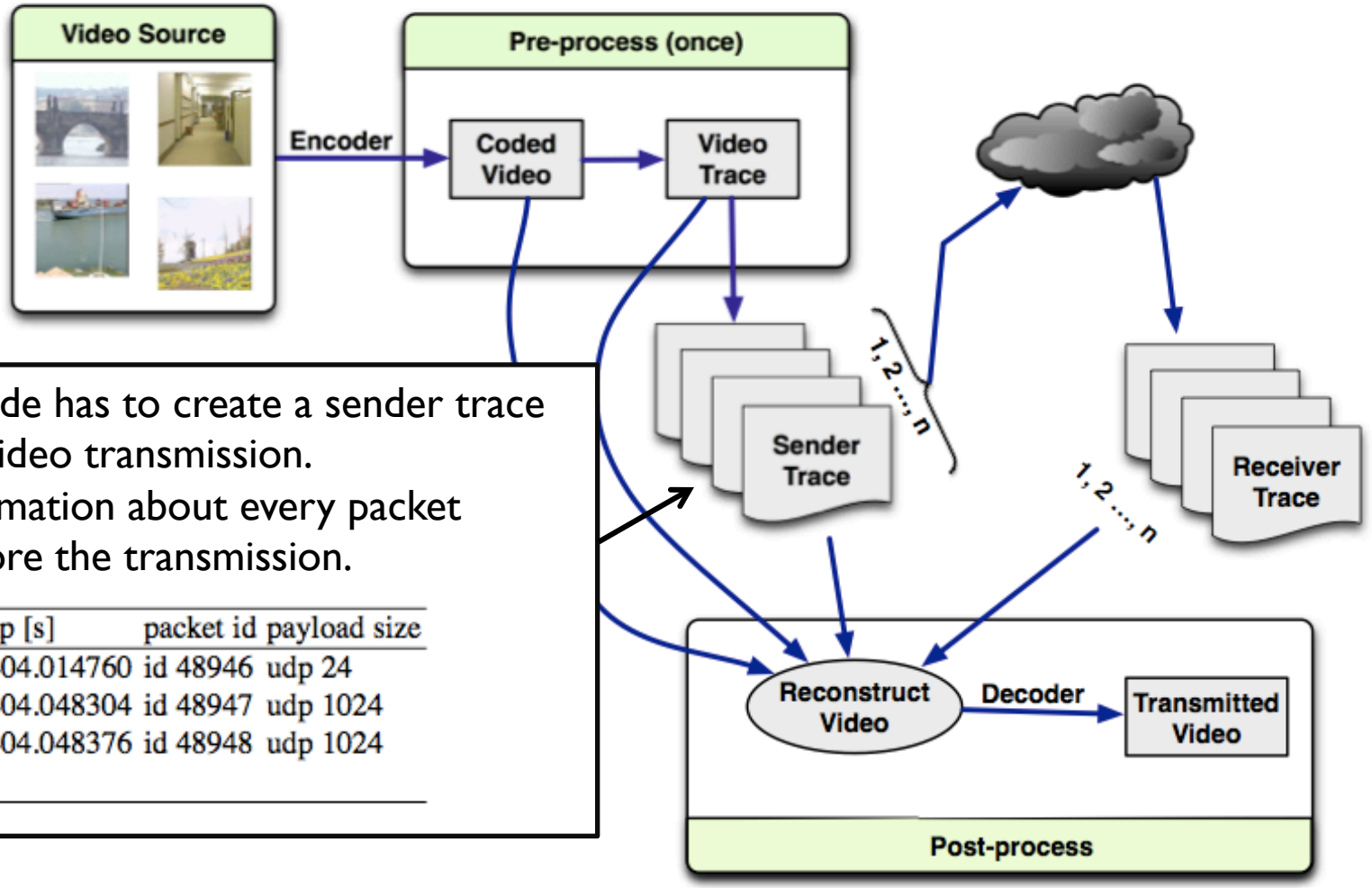


Contains all relevant information about every frame that composes the video.

Frame Number	Frame Type	Frame Size	Number of UDP-packets	Sender Time
0	H	24	1 segm	40 ms
1	I	9379	10 segm	80 ms
2	P	2549	3 segm	120 ms
3	B	550	1 segm	160 ms
...				

GERCOM
Research Group on Computer Networks and Multimedia Communication
UFPA - Brazil

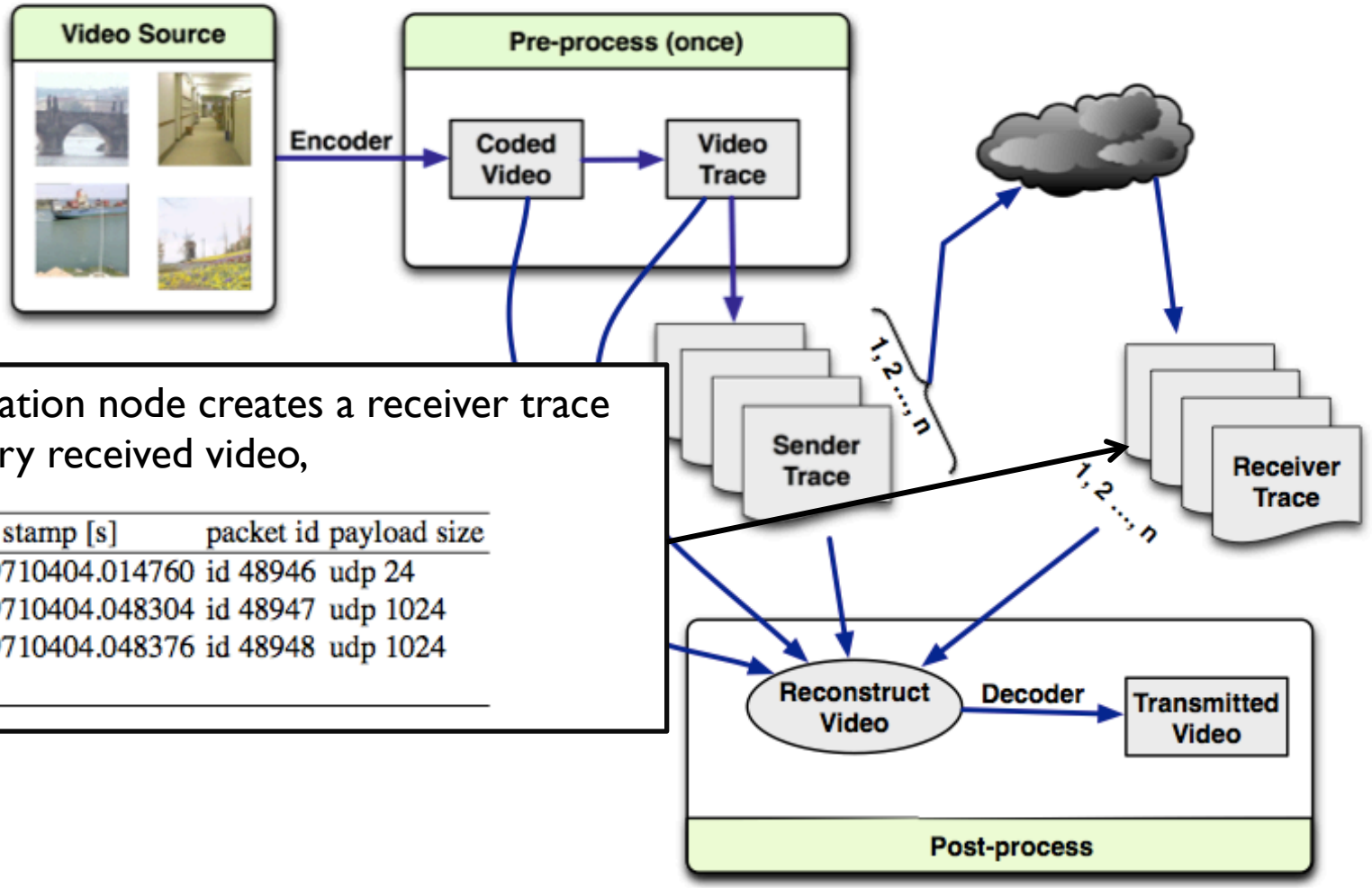
Multimedia management II



The source node has to create a sender trace file for every video transmission.
Contains information about every packet generated before the transmission.

time stamp [s]	packet id	payload size
1029710404.014760	id 48946	udp 24
1029710404.048304	id 48947	udp 1024
1029710404.048376	id 48948	udp 1024
...		

Multimedia management II



The destination node creates a receiver trace file for every received video,

time stamp [s]	packet id	payload size
1029710404.014760	id 48946	udp 24
1029710404.048304	id 48947	udp 1024
1029710404.048376	id 48948	udp 1024
...		

Multimedia management III

- There are basically two QoE approaches:
  - Objective:
    - Peak Signal to Noise Ratio (PSNR);
    - Structural Similarity (SSIM);
    - Video Quality Metric (VQM).
  - Subjective:
    - Mean Opinion Score (MOS)

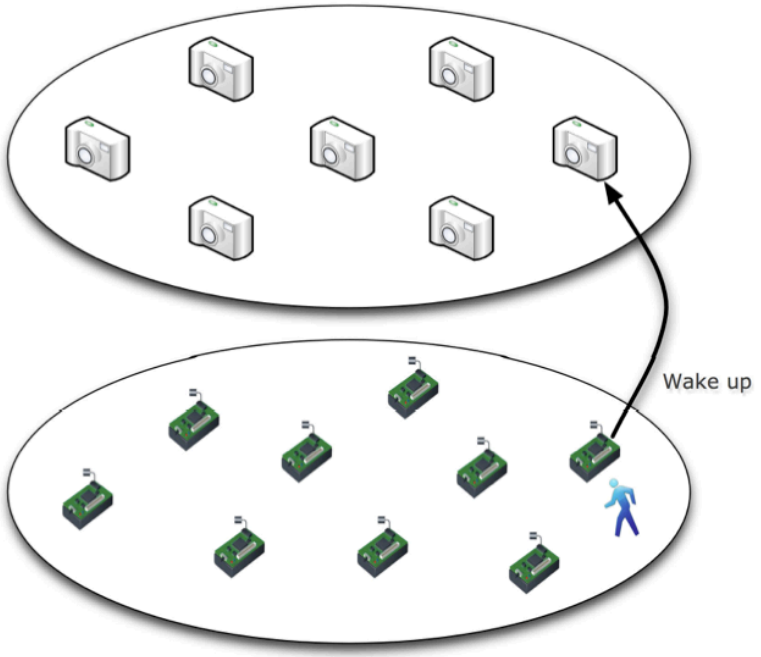
Mobility support

- M3WSN framework relies on BonnMotion at the mobility manager module to fully support different mobility models.
- BonnMotion provides several mobility models.
- Enables the user to configure the energy consumption for a node when it is moving in a certain distance.

Performance Evaluation

Scenario description

- Intrusion detection in multi-tier WMSNs.
- As soon as the low-tier detects the intruder, it must wake up the high-tier to send the video flows.



UNIVERSITÄT BERN
GERCOM
Research Group on Computer Networks and Multimedia Communication
UFPA - Brazil

Scenario description: QoE-aware FEC

- Considers a QoE-aware FEC (Forward Error Correction) mechanism.
- QoE-aware FEC mechanism schemes achieve robust video transmission by sending redundant packets.
- In case of packet loss, the original frame can be recovered from the redundant packets.
- QoE-aware FEC mechanism considers the frame importance and its impact from the user point-of-view to create the packet redundancy.

GERCOM
Research Group on Computer Networks and Multimedia Communication
UFPA - Brazil

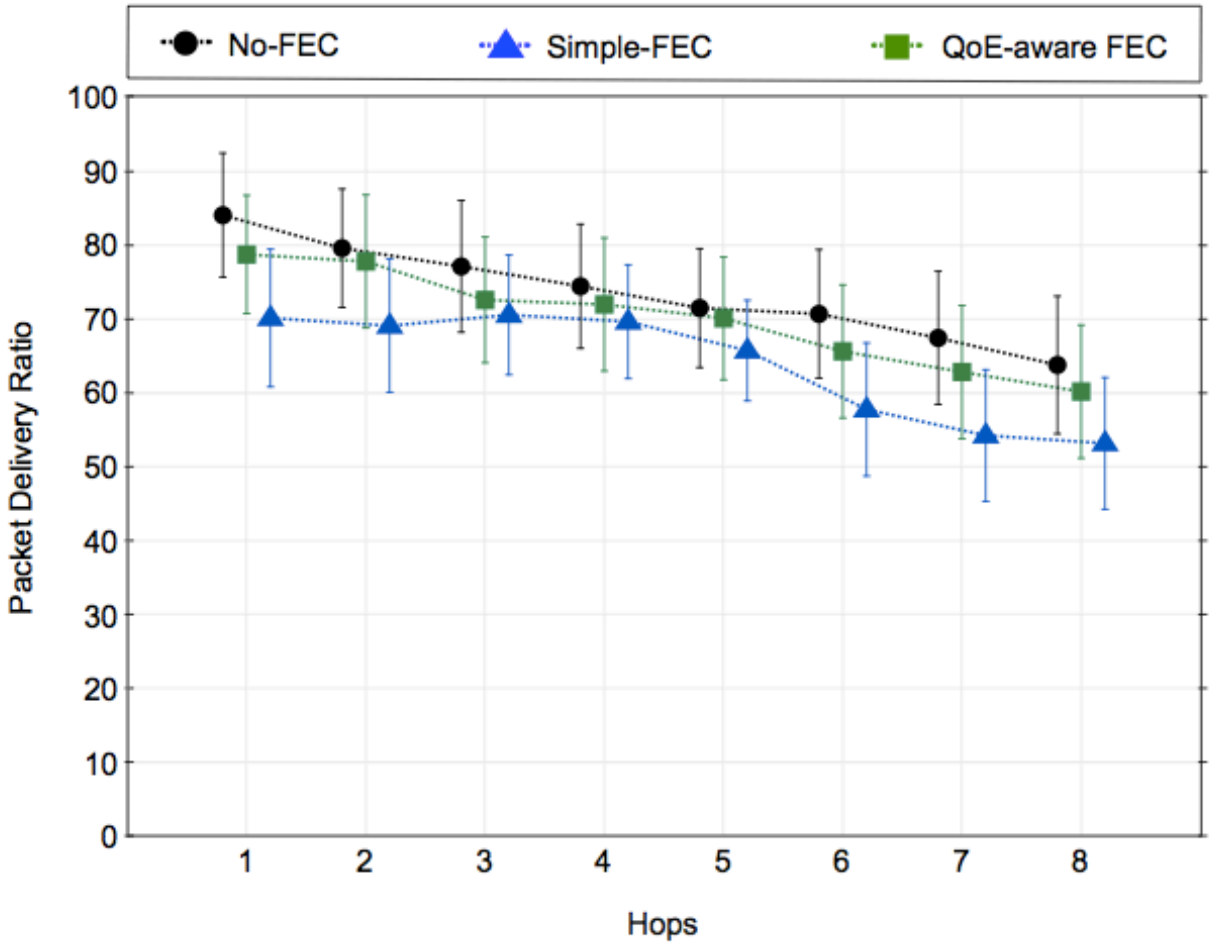
UNIVERSITÄT BERN

* Z. Zhao, T. Braun, D. Rosário, E. Cerqueira, R. Immich, and M. Curado. “QoE-aware FEC Mechanism for Intrusion Detection in Multi-tier Wireless Multimedia Sensor Networks.” In *Proceedings of the 1st International Workshop on Wireless Multimedia Sensor Networks (WiMob’12 WS-WMSN),* Barcelona, Spain, , pp. 689–696, Oct. 2012.

Metrics

- **Quality of Service evaluation**
  - Packet Delivery Ratio (PDR)
- **Objective QoE evaluation**
  - Structural SIMilarity (SSIM)
- **Subjective evaluation**
  - Transmitted frame

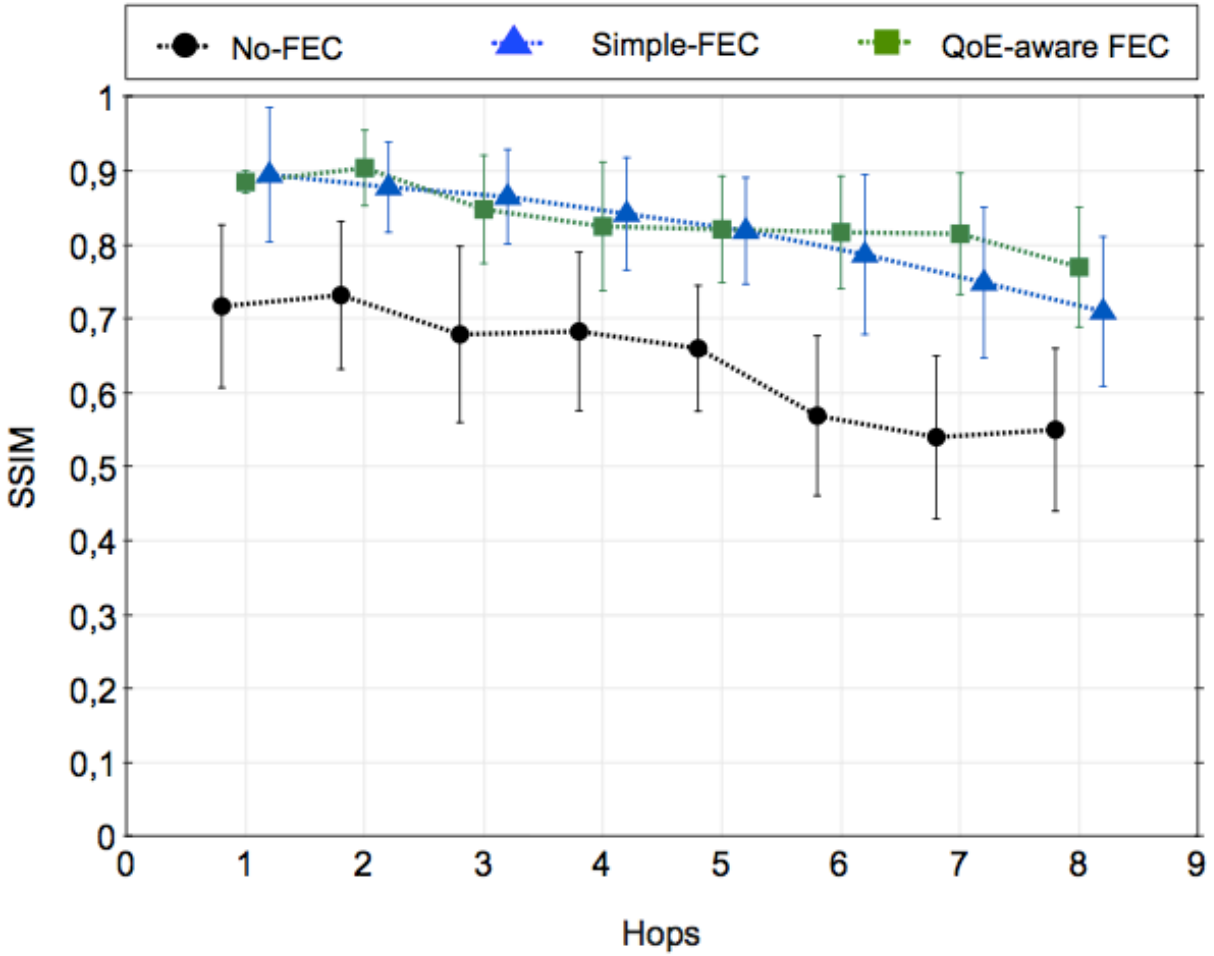
Quality of Service



UNIVERSITÄT BERN

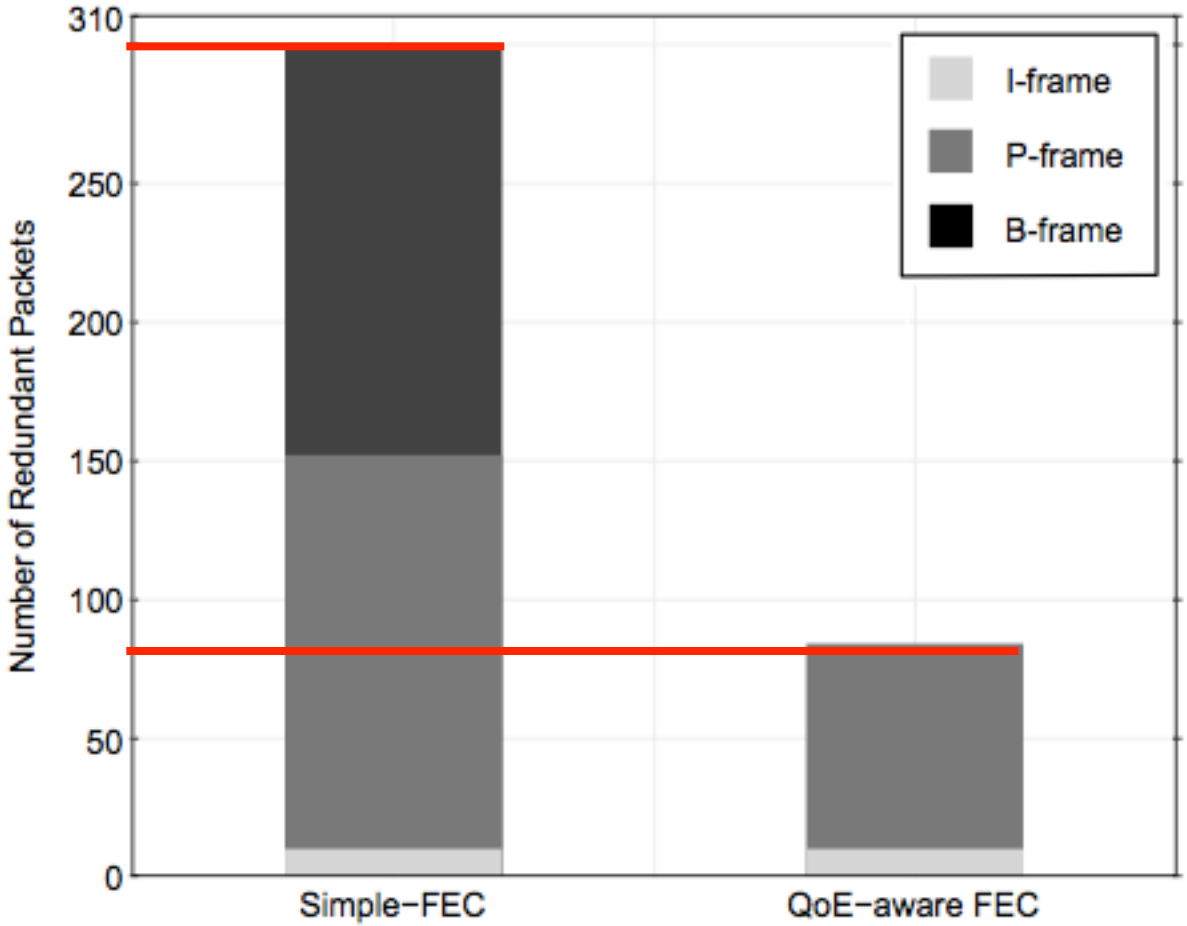
GERCOM
Research Group on Computer Networks and Multimedia Communication
UFPA - Brazil

Quality of Experience



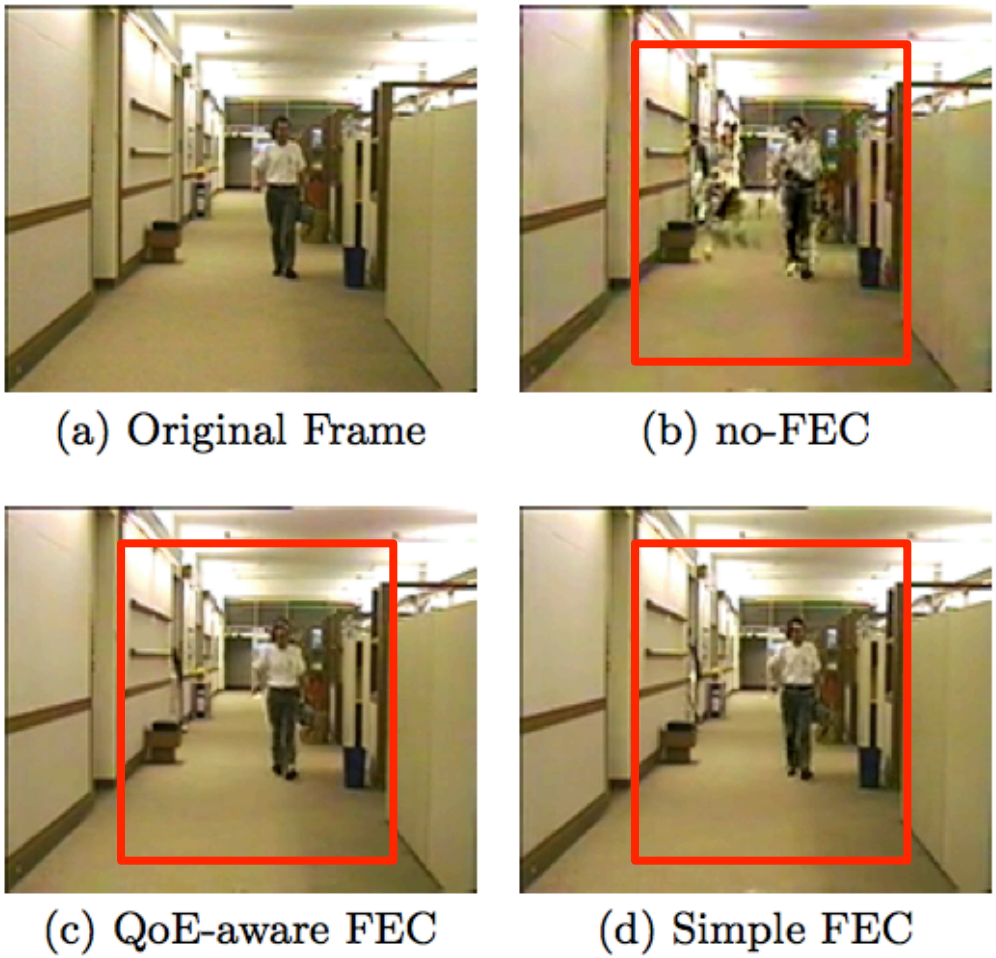
GERCOM
Research Group on Computer Networks and Multimedia Communication
UFPA - Brazil

Network overhead



UNIVERSITÄT BERN
GERCOM
Research Group on Computer Networks and Multimedia Communication
UFPA - Brazil

Frame of transmitted video



(a) Original Frame

(b) no-FEC

(c) QoE-aware FEC

(d) Simple FEC

GERCOM
Research Group on Computer Networks and Multimedia Communication
UFPA - Brazil

UNIVERSITÄT BERN

Conclusions

Conclusion

- M3WSN framework enables the transmission of real video sequence.
- Provide key video-related information.
- This information can be used for creating new assessment and optimization solutions for WMSNs.
- The QoE evaluation are only possible by transmitting real video sequences.

Conclusion

- Node mobility is becoming more important.
- M3WSN framework supports several mobility traces to enable the understanding of how the protocols and algorithm behaves under different mobile situations.

UNIVERSITÄT BERN

GERCOM
Research Group on Computer Networks and Multimedia Communication
UFPA - Brazil

M3WSN will be available at:

http://cds.unibe.ch/research/M3WSN/

rosario@iam.unibe.ch