UNIVERSITÄT BERN

2nd OMNeT++ Community Summit
IBM Research Lab, Zurich

"A Tutorial" of the Mobile Multimedia Wireless Sensor Network OMNeT++ Framework

Zhongliang Zhao, Denis Rosario, Torsten Braun and Eduardo Cerqueira

September 4th, 2015

Outline

UNIVERSITÄT BERN

- 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 easilty 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

UNIVERSITÄT BERN

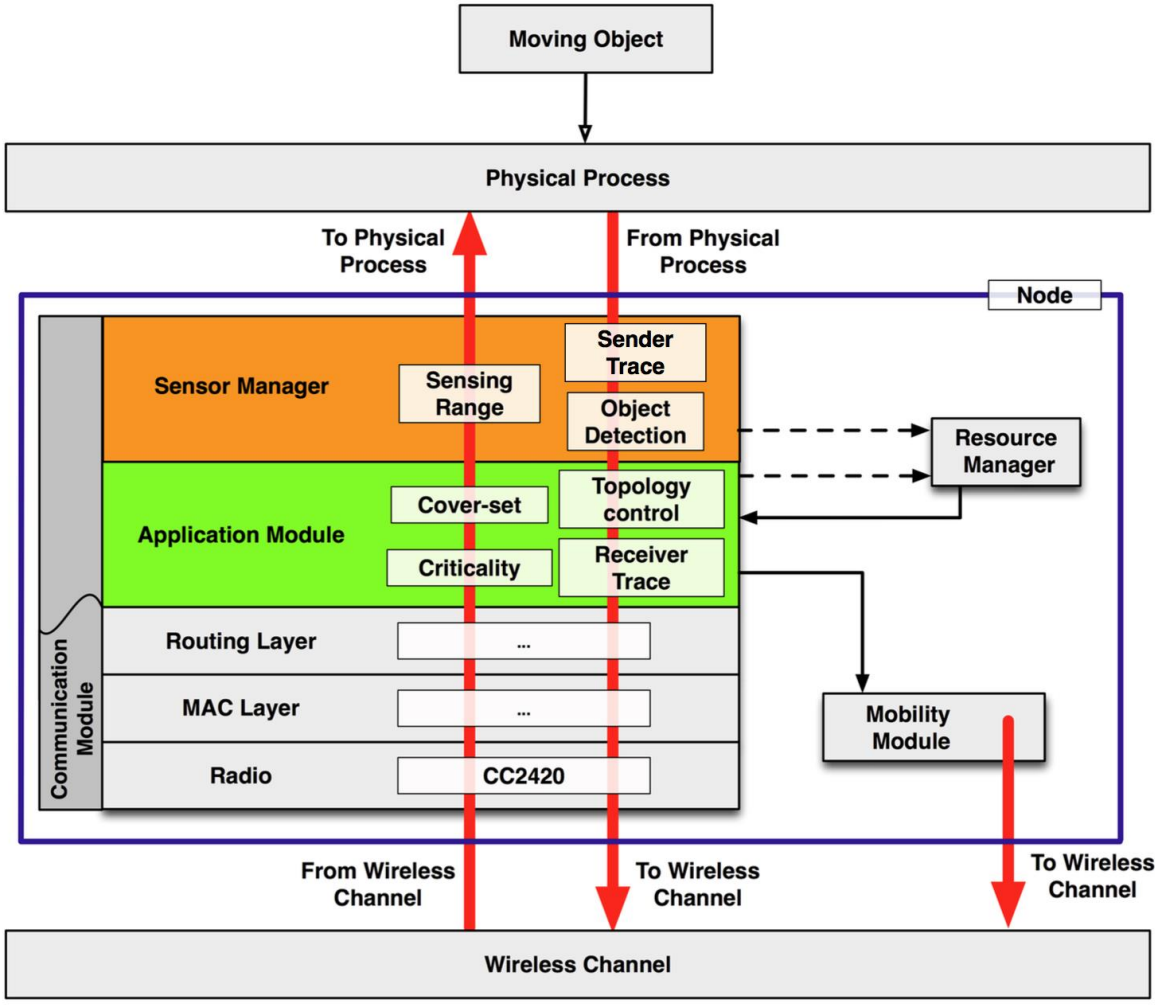
	Pros	Cons
Castalia	• Advanced wireless channel, radio, and power consumption models. • Well-defined architecture	• Does not provide video transmission, control and evaluation. • Includes basic mobility model, e.g., linear mobility. • Does not support moving object.
WiSE-Mnet	• Proposes the use of moving 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.

M3WSN Framework

UNIVERSITÄT BERN

- 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 evauating real video sequences
  - Scenarios consist of fixed and mobile nodes, as well as moving object
  - Measurement of the impact and benefits of novel video-aware algorithms and protocols for fixed and mobile MWSNs

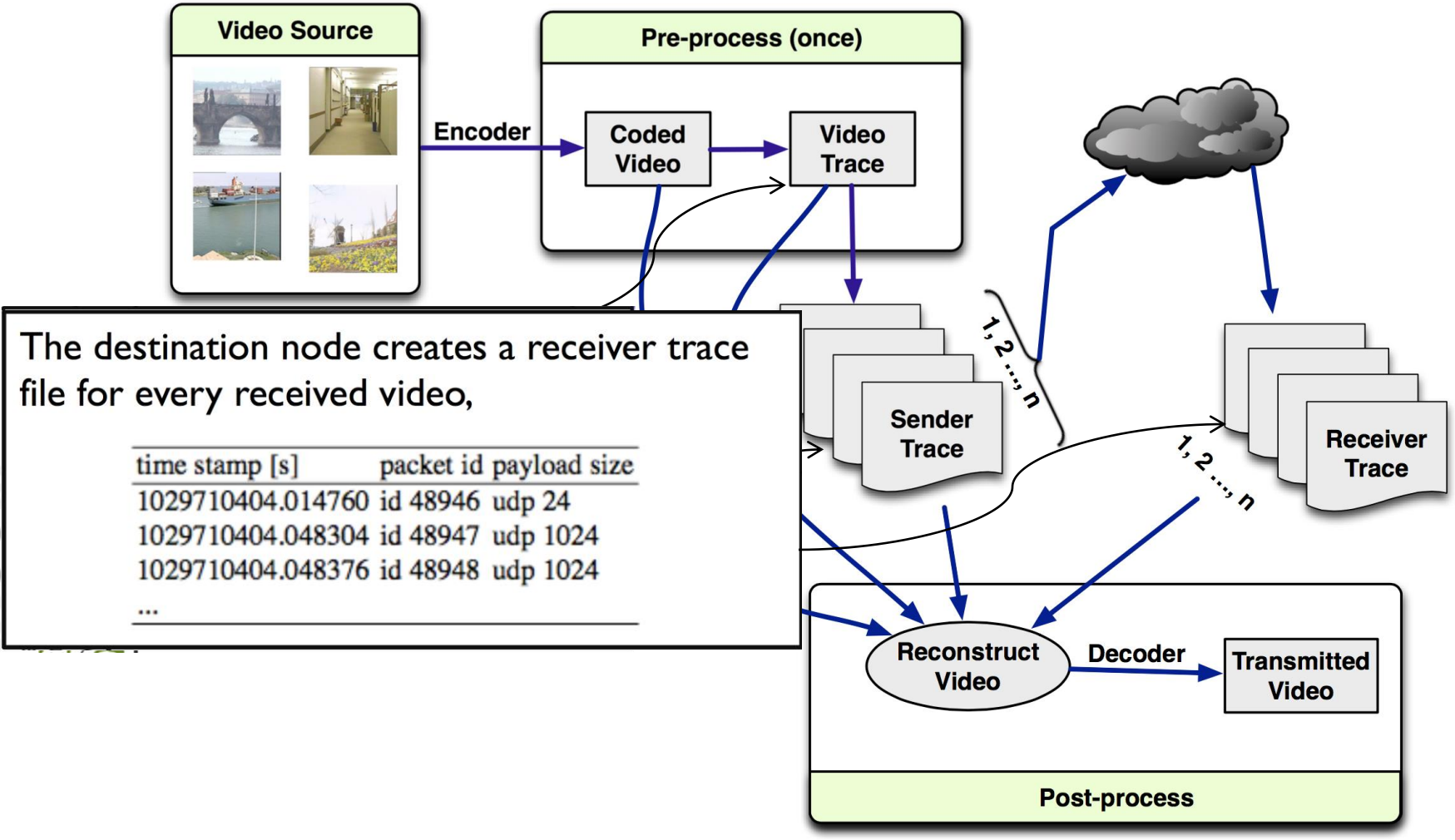
M3WSN Architecture



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

Video Trace Transmission



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
...		

Quality of Experience Support

UNIVERSITÄT BERN

- 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)

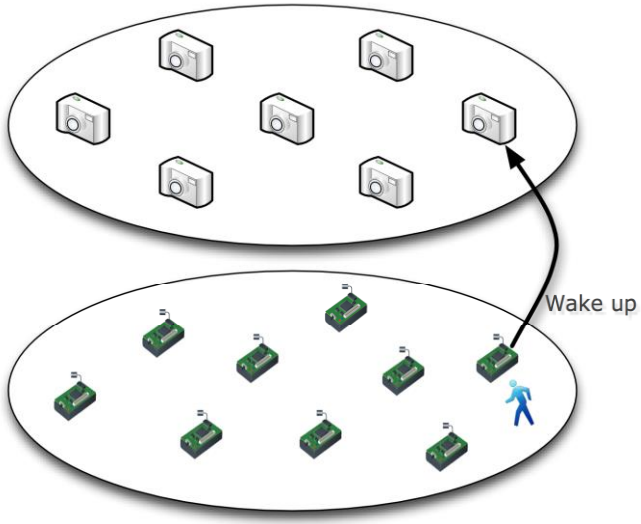
Mobility Support

- 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

UNIVERSITÄT BERN

- 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

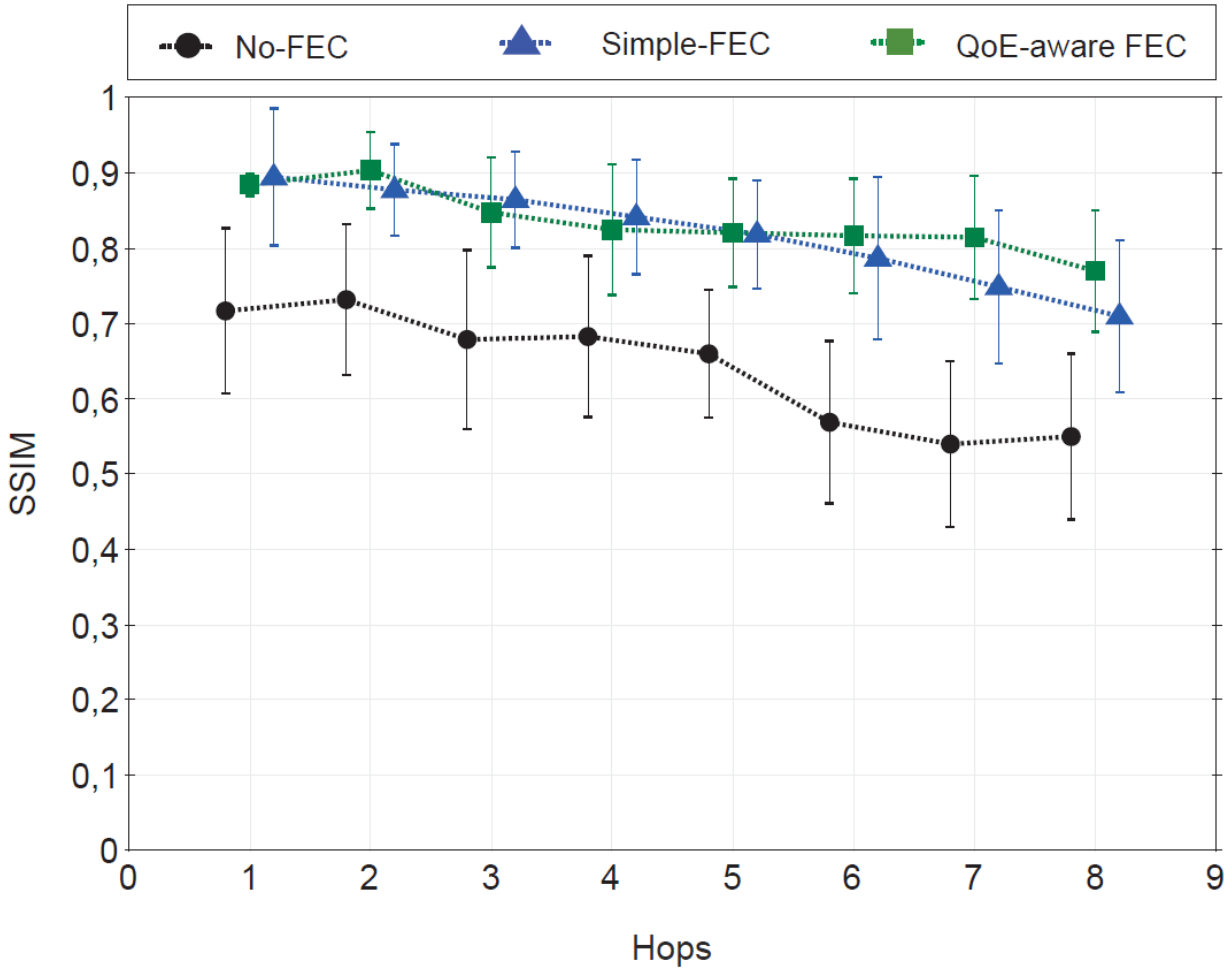
UNIVERSITÄT BERN

- Parameters

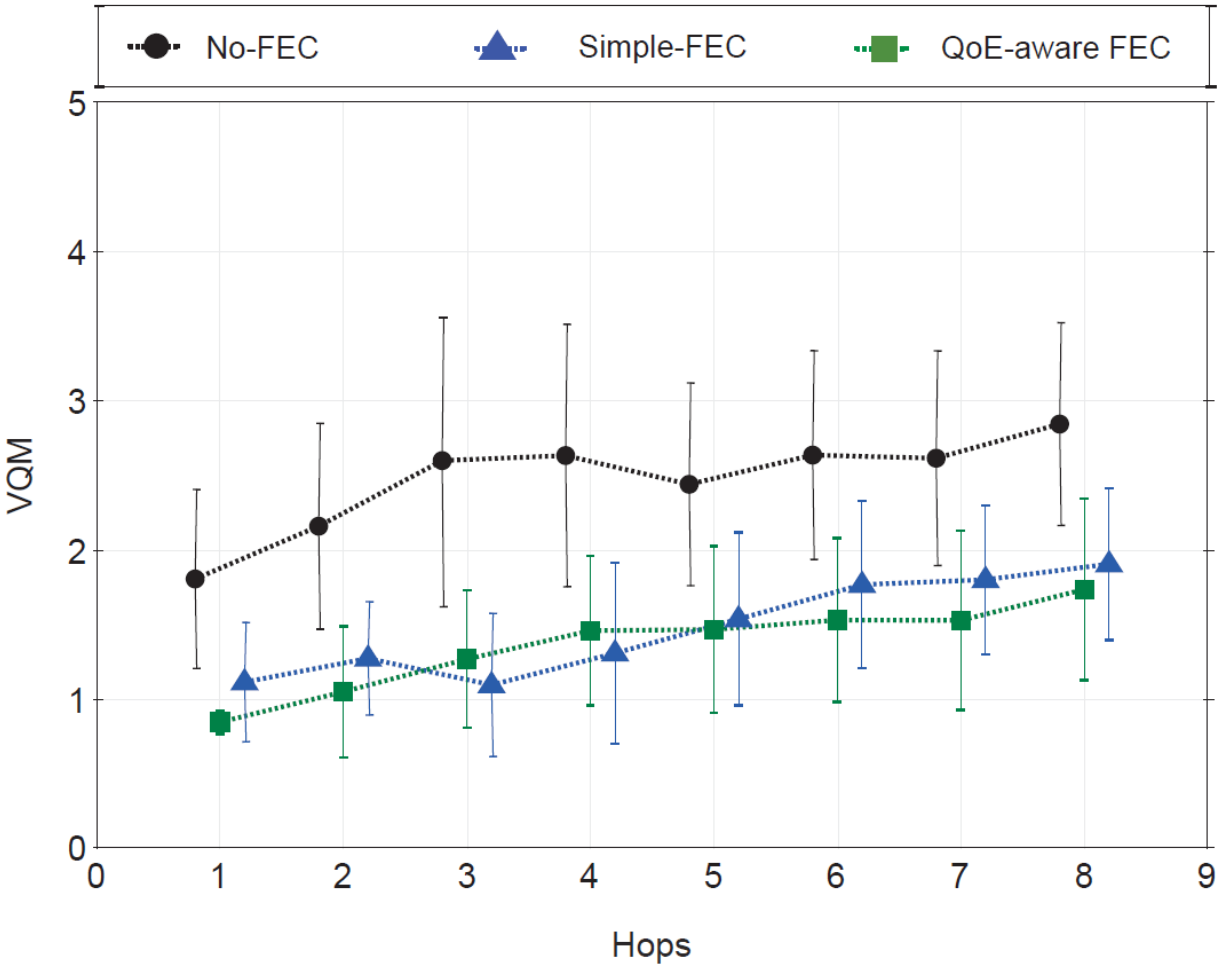
Parameter	Value
Field Size	80x80
Location of Base Station	40, 0
Initial location of intruder	0, 0
Intruder movement type	Random mobility
Intruder velocity	1.5
Total number of Nodes	100
Number of nodes at high-tier	25
High-tier deployment	Grid
Low-tier deployment	Uniform
Transmission Power	-15 dbm
Path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

- Metrics
  - Objective QoE evaluation: SSIM and VQM
  - Subjective evaluation: network overhead and transmitted frame

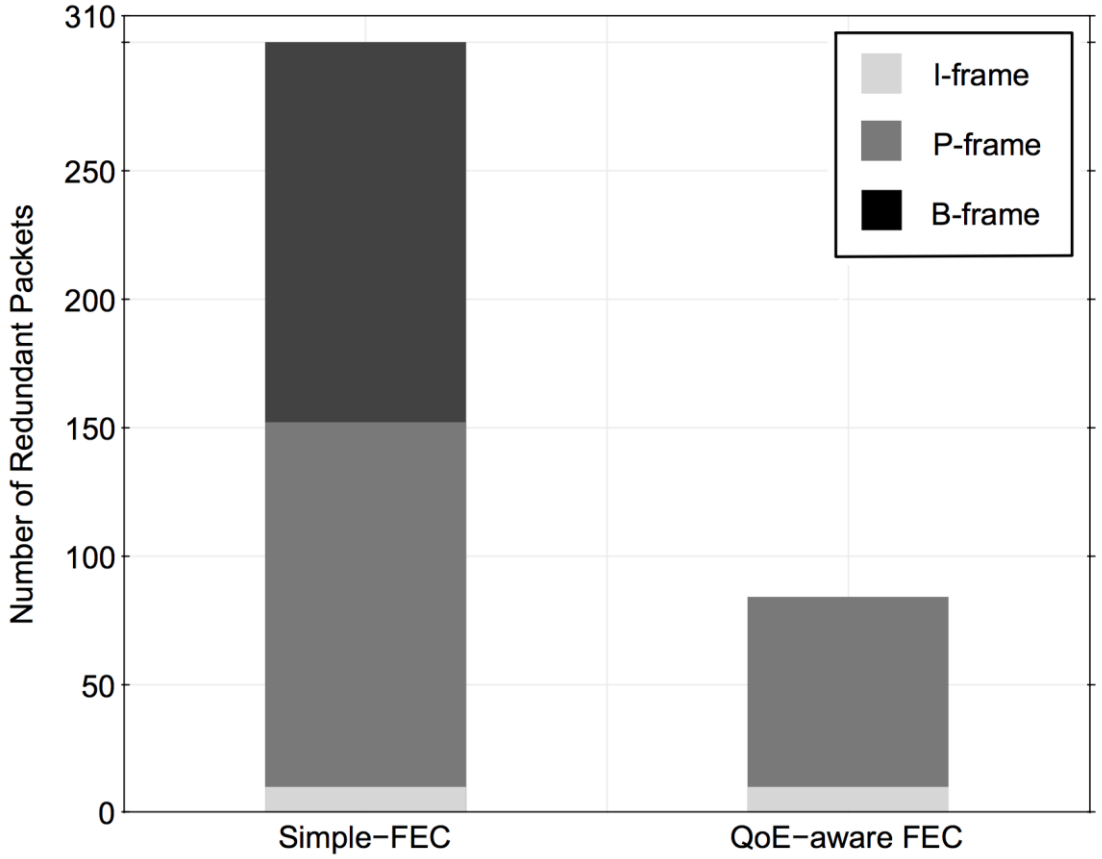
Objective Results: SSIM



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

UNIVERSITÄT BERN

- 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 solutiosn 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/**

Thanks for Your Attention.

UNIVERSITÄT BERN

- zhao@inf.unibe.ch
- http://cds.unibe.ch