A First Study on Video Transmission Over a Nanowireless Network

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Outline

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Motivation

• Nanosensors promise to generate, process, and transmit multimedia content at nano scale

• Very high data rate (theoretically up to several Tbps) in a huge bandwidth (0.1-10 THz)

• In a previous work, we have studied the integration of wireless capabilities in micro-robots of the Claytronics project, showing the enhancement created by wireless communications
Motivation

- Nanocameras could be developed with
  - high sensitivity
  - very low power consumption [1]
- Nanosensors must harvest the energy by converting vibrational, fluidic, electromagnetic or acoustic energy into electrical energy
- A nanosensor could harvest more energy than it will use for packet transmission [2]
- The above properties, allow video application at nanoscale
Motivation

• Video application in nano sensor networks would be used in many fields:
• Application in bio-medical
  • Detect and destroy: Virus, Bacteria [3], Fungi
  • Drug delivery system for disease treatment
  • Observe inner organ with minimum or no surgery
• Application in advance multimedia
  • Real 3D holographic teleconference
  • Advance smart dust technology
• Application in military
  • Nuclear monitoring (in nanoscale)
  • Biological and chemical defenses
Method

- Performance of video application in nano sensor networks needs to be investigated through simulation

- Tools available (NS 3):
  - NanoSim: Throughput and Delay
  - QoE Monitor: Peak Signal to Noise Ratio (PSNR), Structural Similarity (SSIM), and Jitter
Method - NanoSim

• NanoSim allows to evaluate Wireless NanoSensor Networks (WNSN) performance [4]
• NanoSim comprises three types of WNSN devices:
  • Nanonode: It is the smallest device and it can be seen as a sensor collecting information such as chemical reaction or multimedia content (sound, image and video). This device has limited capabilities in computational, storage and communication range
Method - NanoSim

- **Nanorouter**: This device has larger capabilities than a nanonode, it can receive and forward information to the nanointerface or to other nanorouters.

- **Nanointerface**: This device can be considered as the sink which processes information from sensors. This device can also be used as a gateway to another network e.g.: WiFi, LTE, etc.
Method - NanoSim

- The network architecture consists of four layers:
  - Application Layer (Message Processing Unit class)
    - Generates packets using Constant Bit Rate (CBR)
    - Receives packets from the lower layer
  - Network Layer
    - Receives/forwards packets between nanosensors and nanorouters to nanointerfaces
Method - NanoSim

- Medium Access Control (MAC)
  - Transmits packets from network layer to physical layer without any control
  - Sends the packets when at least one node is in its transmission range
- Physical Layer.
  - Operates in Terahertz spectrum using TS-OOK modulation
Method - QoE

- Quality of Experience (QoE) Monitor is an NS3 module
- Computes PSNR and SSIM metrics
- At the transmitter side, the video source uses the RTP protocol to fragment the original video into packets.
- Sender: header information like packet ID, payload size, and timestamps are added.
- Receiver: extracts the header from each packet and creates the reconstructed video.
Method

• Peak Signal to Noise Ratio (PSNR) measures distortion between the received video and the original
• Structural Similarity (SSIM) quantifies loss of image structural information; it uses sliding windows shifted pixel by pixel on each single frame
• Jitter is the variation of end-to-end delay between packets

• Nano-sim patch, Qoe patch, and nanovideo streaming application available:
  • http://eugen.dedu.free.fr/publi/nanovideo/
Method

• We used two network topologies for the tests:
  • The first has two nodes, and is used to check the simulator with the two modules (QoE monitor and Nano-Sim)
  • The second has one source, one destination and 16 relays, and is used to discover how communication is done in a multi-hop nanonetwork
• The video file used as input is the classical “news” sequence in CIF resolution
Simulation Result

• The PSNR has a relatively low value (20 to 35 dB) and is quite regular
• No packet is lost on the network; but the reordering done by NanoSim, makes QoE monitor drop packets at receiver

*The PSNR for 2-nodes network.*
Simulation Result

• The abrupt changes in PSNR plot, appearing at frames 45, 80 and 130, correspond to abrupt scene changes in video file.
• The PSNR for 18-nodes network, is similar to the one for 2-nodes and exhibits the same properties.

The PSNR for 18-nodes network
Simulation Result

• SSIM curve varies more at abrupt scene changes, but it is less visible, except for frame 130
• The SSIM curve for 2-nodes network is similar to 18-nodes network
Simulation Result

- Jitter varies generally between 30 ns and 70 ns. These values are 3 orders of magnitude lower than what is currently found on Internet, which are of order of tens of ms.
- As a consequence, the buffers at receiver side could potentially be much smaller than the ones on Internet.
Conclusion & Future Works

• Current simulation showed the limitation of the tools and their models. Unordered packets provide non realistic simulation.

• Research in this field needs better tools and models for such studies.

• Such a tool should take into account channel contention, transmission delays, a more realistic packet loss pattern, allow to read and write video files even at high bitrates, and, last but not least, give reliable results.
Conclusion & Future Works

• Find methods for specific nanowireless channel coding for multimedia
• Take advantage of low-weight coding for multimedia content
  • Increase the proportion of “O” in the media
  • Minimize the interferences between different senders/receivers
  • Enhance energy consumption of the whole system
## References

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