Header Compressed VoIP in IEEE 802.11

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Introduction

- Wireless networks are providing high bandwidths to users and enabling real-time multimedia applications.
- Multimedia applications may generate real-time high-bit-rate flows. At the wireless access networks, the provisioning of high bit rates can be done using a set of techniques including more spectrum, smaller cells, and new adaptive modulations.
- A typical IPv6 VoIP packet includes a 40-byte IP header, an 8-byte User Datagram Protocol (UDP) header, a 12 byte Real-Time Transport Protocol (RTP) header, and a 20-byte payload.
Assuming that the voice traffic currently transported by systems such as the Global System for Mobile Communications (GSM) migrates to fourth-generation (4G) packet-switched networks, the amount of VoIP traffic is expected to become significant in the latter networks. These two assumptions combined, significant amounts of real-time traffic and large relative overheads, justify the study of header compression (HC) techniques and their value in future wireless networks.
RoHC (Robust Header Compression) Protocol

- Established between two adjacent IP nodes that also behave as the RoHC compressor and RoHC decompressor.
- Each context is identified by a context ID (CID), which is included in the header of all RoHC packets.
- The RoHC compressor state machine contains the Initialization and Refresh (IR) state, the First Order (FO) state, and the Second Order (SO) state.
RoHC can operate in three modes: **unidirectional (U-mode)**, **bidirectional optimistic (O-mode)**, and **bidirectional reliable (R-mode)**.

- In the U-mode, packets are only sent in one direction: from compressor to decompressor. This mode therefore makes ROHC usable over links where a return path from decompressor to compressor is unavailable or undesirable.

- In the R-mode, a more intensive usage of the feedback channel and a stricter logic at both the compressor and the decompressor that prevents loss of context synchronization between compressor and decompressor except for very high residual bit error rates.

- In the O-mode, except that a feedback channel is used to send error recovery requests and (optionally) acknowledgments of significant context updates from the decompressor to compressor. The O-mode aims to maximize compression efficiency and sparse usage of the feedback channel.
- U-mode compressor state machine
New VOIP packet
Create CID 1
IR state
IR-RoHC packet (CID=1, payload=80 bytes)
Create CID 1
Update CID 1
Update CID 1
(more packets are sent in SO state, and correctly decompressed by the Decompressor)
Full queue packet dropped
Decomp. error packet dropped
Full queue packet dropped
Full queue packet dropped
IP timeout
IR state
Rebuild context CID=1
Rebuild context CID=1
Header Compressed VoIP over 802.11

- This section presents our simulation study of the RoHC’s U-mode performance when applied to VoIP in an 802.11 link.
- The simulations were carried out using Network Simulator 2 (NS-2) and an IEEE 802.11a model. The objectives of the study are twofold:
  - To characterize the performance of the RoHC’s U-mode when applied to VoIP in an IEEE 802.11a link in terms of gains in data throughput and delay — covered by the RoHC performance experiments
  - To propose values for the U-mode’s parameters that maximize its performance over an 802.11 link — covered by the RoHC parameters experiment
The RoHC performance experiments address two situations:

- The **802.11a link under heavy utilization (congestion)**—the RoHC performance experiment with FTP
- The **802.11a link utilization under low utilization**—the RoHC performance experiment with HTTP
Simulation Scenario and Model

- The G.729 VoIP codec is commonly used. It generates constant bit rate (CBR) traffic of 8kb/s and a packet payload size of 20 bytes.
- The simulation model uses IPv4 at the network layer.
- Simulation scenario
Measuring HC Gain

- In order to characterize RoHC’s value, a new compression metric was defined, RoHC’s gain ($RoHCGain$).

$$RoHCGain = \frac{Total\ Payload\ Reved\ Using\ RoHC}{Total\ Payload\ Reved\ Not\ Using\ RoHC} - 1$$

- $RoHCGain$, as well as other parameters required for RoHC characterization, are represented as a function of the percentage of uncompressed VoIP traffic received in the 802.11 link.

$$VoIP\ Traffic\ Received = \frac{VoIP\ Payload\ Reved}{Total\ Payload\ Reved\ Not\ Using\ RoHC}$$
RoHC Performance Experiment with FTP

- For each MT included in a simulation run, a single RoHC-compressed bidirectional VoIP connection is established between each MT and the GW.

- Thus, the number of MTs, excluding the MT_Load node, equals the number of VoIP calls in the 802.11 link.

- In all the simulation runs the MT_Load establishes a 1500-byte packet FTP connection to the GW, used to transfer a very large file; therefore, there is always data to be transmitted.
Due to the TCP congestion control mechanism, the FTP connection tries to use all the bandwidth available, giving a good estimate of the bandwidth saved by RoHC.

Simulation runs were executed up to VoIP traffic reaching 90 percent of all the traffic received.

By measuring the data throughput of all flows when not using RoHC and comparing it with the data throughput when using RoHC.
When the number of VoIP calls increases, the percentage of VoIP traffic in the link also increases, and the TCP source adapts itself by sending less data.

The throughput decreases with the increase of the percentage of VoIP traffic in the 802.11 link because more stations try to access the medium and packets are mostly of small length.
- When RoHC is used, the load offered by VoIP sources to the medium is reduced (smaller headers), and the TCP source is able to send more data.
- As a consequence, the TCP flow adapts itself and transmits less data.
RoHC Performance Experiment with HTTP

- The RoHC performance experiment with HTTP represents a scenario where a user at the MT_Load is browsing Websites.
- Because users take time to read Web pages, HTTP traffic is only transmitted occasionally.
- Therefore, this experiment differs from the experiment with FTP because the VoIP traffic is mixed with short-lived TCP flows, resulting in much lower link utilization and delays.
- In this scenario, the TCP flows do not try to use the bandwidth freed by the use of RoHC; therefore, when considering our RoHCGain metric, RoHC produces no gain.
RoHC Performance Results
RoHC Parameters Experiment

- The results obtained show that for near zero packet loss (~ 0 percent), the optimum values of the IR_TIMEOUT and FO_TIMEOUT are 10 and 9, respectively; for low packet loss (0.01–2 percent), these values are 9 and 4; and for high packet loss (> 2 percent), they are 6 and 3.
Conclusions

- HC techniques, such as those included in RoHC, reduce the amount of overhead data transmitted in IP-based communications.

- The study showed that the use of RoHC is beneficial only when the 802.11 link experiences some degree of congestion or transports greedy flows; in this case, the results obtained indicate a maximum $RoHCGain$ of 23 percent for medium voice quality.

- When the utilization of the wireless link is low, with congestion occurring only temporarily, the use of RoHC seems to be dispensable unless there is some economical benefit in transporting the same amount of application data using fewer bytes.