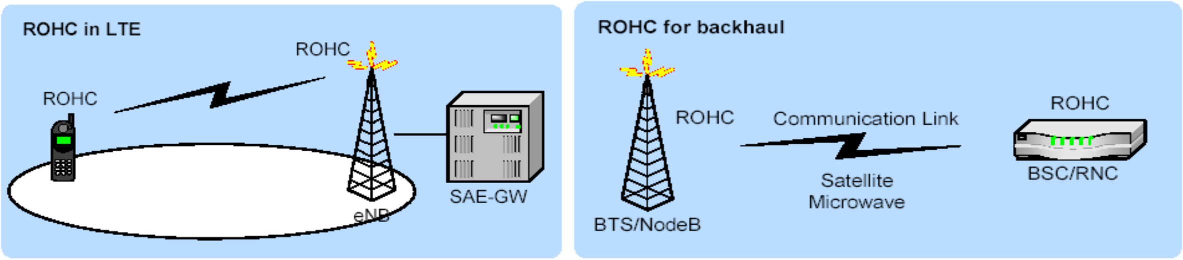
The Effnet ROHC Portfolio for LTE and NR

Effnet ROHC portfolio for LTE and NR consists of software products based on various RFCs which define RObust Header Compression (ROHC). ROHC is a header compression algorithm and protocol standardized by IETF. Effnet ROHC portfolio for LTE and NR provides significant improvements in link efficiency for TCP traffic e.g. web, file transfers etc., RTP and UDP traffic e.g. real time, interactive and streaming applications, ESP traffic e.g. secure traffic and IP traffic e.g. tunnelled IPv6 traffic over high BER, long RTT links.

ROHC is recommended by 3GPP for efficient use of radio resources since Release 4 onwards. It is an important component of the IP Multimedia Subsystem (IMS). ROHC is also used to improve efficiency in many other data networks such as satellite, WAN and ad-hoc (military applications) etc.



3GPP's Long Term Evolution (LTE) project focuses on enhancing the Universal Terrestrial Radio Access (UTRA) and optimizing radio access architecture, and the 5G New Radio (NR) project aims to further improve the radio access technology to enable three new use cases; enhanced mobile broadband (eMBB), ultra-reliable low latency communications (URLLC) and massive machine-type communications (mMTC). LTE and NR has adopted packet-switch technology using end-to-end IP communication instead of traditional circuit-switching. The LTE and NR specifications for Packet Data Convergence Protocol (TS 36.323 and TS 38.323) specify use of ROHC. It supports the following header compression protocols and profiles:

Profile Identifier	Usage:	Reference
0x0000	No compression	RFC 4995/RFC 5795
0x0001	RTP/UDP/IP	RFC 3095, RFC 4815
0x0002	UDP/IP	RFC 3095, RFC 4815
0x0003	ESP/IP	RFC 3095, RFC 4815
0x0004	IP	RFC 3843, RFC 4815
0x0006	TCP/IP	RFC 4996/RFC 6846
0x0101	RTP/UDP/IP	RFC 5225
0x0102	UDP/IP	RFC 5225
0x0103	ESP/IP	RFC 5225
0x0104	IP	RFC 5225

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Effnet ROHC portfolio for LTE and NR consists of the following products:

Product	Usage	Profile Identifiers	References
Effnet ROHC™	No Compression, RTP/UDP/IP, UDP/IP, ESP/IP, IP	0x0000, 0x0001, 0x0002, 0x0003, 0x0004	RFC 3095, RFC 3843, RFC 4815
Effnet ROHC-TCP™	TCP/IP	0x0006	RFC 4996/RFC 6846
Effnet ROHCv2™	RTP/UDP/IP, UDP/IP, ESP/IP, IP	0x0101, 0x0102, 0x0103, 0x0104	RFC 5225

Effnet ROHC portfolio for LTE and NR can be optionally complemented with a test environment, *Effnet HC-Sim™*, which can simulate IP traffic on configurable link conditions, e.g. bit errors, packet loss, reordering etc.

Standards Compliance

- IETF standards
    - RFC 3095 “RObust Header Compression (ROHC)”
    - RFC 3843 “RObust Header Compression (ROHC): A Compression Profile for IP”
    - RFC 4815 “RObust Header Compression (ROHC): Corrections and Clarifications to RFC 3095”
    - RFC 4995/RFC 5795 “The RObust Header Compression (ROHC) Framework”
    - RFC 4996/RFC 6846 “RObust Header Compression (ROHC): A Profile for TCP/IP (ROHC-TCP)”
    - RFC 4997 “Formal Notation for RObust Header Compression (ROHC-FN)”
    - RFC 5225 “RObust Header Compression Version 2 (ROHCv2): Profiles for RTP, UDP, IP, ESP and UDP-Lite”

Standards referral

- IETF standards
    - RFC 3241 “ROHC over PPP”
    - RFC 3759 “RObust Header Compression (ROHC): Terminology and Channel Mapping Examples”
    - RFC 3816 “Definitions of Managed Objects for RObust Header Compression”
    - RFC 4224 “RObust Header Compression (ROHC): ROHC over Channels that can Reorder Packets”
- Other standards
    - 3GPP TS 25.323, TS 36.323 and TS 38.323 Packet Data Convergence Protocol (PDCP)
    - 3GPP TS 44.065 SubNetwork Dependent Convergence Protocol (SNDCP)
    - Compliant with 3GPP IP based Multimedia Service (IMS) requirements
    - Compliant with 3GPP Multimedia Broadcast Multicast Service (MBMS) requirements

Portability and ease of integration

Effnet ROHC portfolio for LTE and NR has been ported to and integrated on many different platforms. The operating systems include VxWorks, Nucleus, Linux, Windows (2000/XP), Solaris, FreeBSD and processors include PowerPC, MIPS, ARM, SPARC and x86. As the products are highly portable, they can be easily ported to many other operating systems, both real-time and generic as well as to other processors, both 32-bit and 64-bit regardless of byte-order.

- Highly portable code
    - is written in ANSI C
    - has variable types defined such that the variables behave the same way across different compilers.
    - is memory alignment safe.
    - is endianess independent.
    - does not require OS timers and does not have OS dependencies.
    - is re-entrant.
- A well defined Application Programming Interface (API)
    - a set of functions and parameters.
    - documentation and sample application code.
    - provides control of memory management.
    - provides control over multi-threading of the application.
- Small memory footprint and low CPU power requirement

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  - makes it suitable for both mobile terminals as well as large system nodes like eNB, RNC, PDSN, ASN-GW etc.
- A sample application demonstrates how to use the API which speeds-up the integration process.
- Interoperable
  - Has been extensively tested during field tests by customers, all the ROHC interoperability tests conducted by IETF and internal rigorous quality process.

Additional features
In addition to the features specified in the standards, the Effnet ROHC portfolio for LTE and NR has the following efficiency and robustness improving features:

- Full featured and efficient classification and context management module.
- Highly efficient compression and decompression using field pattern change detection algorithm and link layer information when available.
- Support for handover via context re-initialization.
- Support for AT reboot via feedback options, the decompressor reinstates the compressor context information.
- Mechanisms to reduce usage of feedback channel.
- Support for chained memory buffer.
- Interactive statistics and callback functions.
  - User can read and/or reset statistical information at desired time intervals. The callback functions provide useful state information.
- Dynamic channel parameter configuration.
- Adaptive mechanisms for improved compression efficiency & context damage detection under various channel conditions.
- List Compression and many of the channels and flow specific parameters, are highly configurable.

All additional features above are transparent with regard to interoperability.

Effnet Classifier and context manager™

Classification and context management is essential to header compression. Effnet provides this additional module together with the Effnet ROHC product family. The classifier and context manager has the following properties:

- Small memory footprint.
- Small per-packet computing overhead.
- Handles typical classification requirements for header compression flows.
- Performs exact matching on all required header fields for ROHC, including IP version (IPv4 or IPv6), Source address, Source port, Destination address, Destination port, RTP SSRC (in special case).
- Handles AH, GRE and MINE headers.
- Handles IPv6 extension headers (sometimes used within IPv4, if tunneled).
- Detects and avoids fragmentation and IPv4 options.
- Provides profile hint for a packet based on header chain present.
- Provides context associated with a packet via context management.

Effnet ROHC™

The VoIP enabler on wireless networks! Effnet ROHC™ is an important component to run VoIP services efficiently over wireless networks. Most of the RTP applications use UDP for signaling purposes and there are many stand-alone UDP applications, so the support for IP/UDP compression adds further to the efficiency. There is significant demand for secure exchange of information which leads to increased header overhead. The capability to compress IP/ESP, the header overhead in secure connections, makes it possible to run secure networks without additional bandwidth. As more and more networks are moving to support IP based communications, the number of nodes that require IP address are increasing rapidly. The introduction of IPv6 should address this concern but at least during transition time, a lot of traffic will be sent via tunnels across

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networks. The support for compressing layers of IP headers makes it possible to run tunneled traffic without need for additional bandwidth.

The following features of RFC 3095, RFC 3843 and corrections as suggested in RFC 4815 are implemented and apply to all profiles unless stated otherwise.

- All profiles: 0 (UNCOMPRESSED), 1 (RTP), 2 (UDP), 3 (ESP) and 4 (IP) are supported.
- All the compressor states (IR, FO and SO) and the state transitions.
- All the decompressor states (NC, SC and FC) and the state transitions.
- All modes and mode transitions: Unidirectional (U-mode), Bi-directional Optimistic (O-mode), and for profiles 1, 2 and 3 also Bi-directional Reliable (R-mode).
- Encoding methods : LSB, W-LSB, Scaled RTP Timestamp, Timer-based compression of RTP Timestamp, Offset IP-ID encoding, Self-describing variable-length values
    - Transitions to and from Timer-based compression of RTP Timestamp (profile 1).
- Parsing and handling of all ROHC packet types, including all extensions: 0, 1, 2, and 3.
- Parsing and handling of all ROHC feedback packets (piggyback and interspersed) and options.
- Local repair mechanisms as required in RFC 3095 sections 5.3.2.2.4 - 5.
- Compression of both IPv4 and IPv6 headers.
- Dealing with changes in semi-static fields, e.g., TTL, TOS, DF-bit, and RTP payload type, RTP X and P bits (the last three is for profile 1 only).
- Heuristics for detection of IP-ID behavior and dealing with its changes.
- Support for constant IP-ID (profile 4 only).
- Compression of CSRC and extension header lists (type 0 in compressor and all types in decompressor).
- Compression of outer IPv4 or IPv6 header; dealing with the same kinds of changes as for the inner IP header.
- Compression of extension header list in outer IP header.
- Segmentation with packet size limitation enforcement & Reassembly.
- Reverse Decompression.
- Support for static chain termination (profile 4 only).

Effnet ROHC-TCP™

Multiple Internet packet size studies are in agreement that at least 40% of all IPv4 packets carry no or only a few bytes of payload i.e. packet sizes are at or very near to header size (IPv4+TCP). One study of IPv6 packets shows the same trend. Even more remarkable in that study is that for IPv6, 60-80% packets carry more header data than packet data. Effnet ROHC-TCP™ would be very beneficial in these cases.

The following parts of RFC 4996/RFC 6846 are implemented:

- Profiles: 0x0006 (ROHC-TCP) is supported.
- All the compressor and decompressor states and the state transition.
- Both modes: Unidirectional (U-mode), Bi-directional Optimistic (O-mode) and mode transitions.
- Encoding methods: LSB, W-LSB, Offset IP-ID encoding, Self-describing variable-length values
- Context initialization using IR packet.
- Optimistic approach and periodic context refresh.
- Compression and decompression of IPv4 and IPv6 with extension headers.
- Compression and decompression of AH, GRE, ESP-NULL and MINE headers.
- Compression and decompression of TCP header.
- IR and IR-DYN packet types.
- Dealing with changes in semi-static fields, e.g., TTL, TOS and DF-bit.
- Heuristics for detection of IP-ID behavior.
- Dealing with changes in IP-ID behavior.
- Support for packet all types
    - Packet types for both random and sequential IP-ID are supported.

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Effnet ROHCv2™

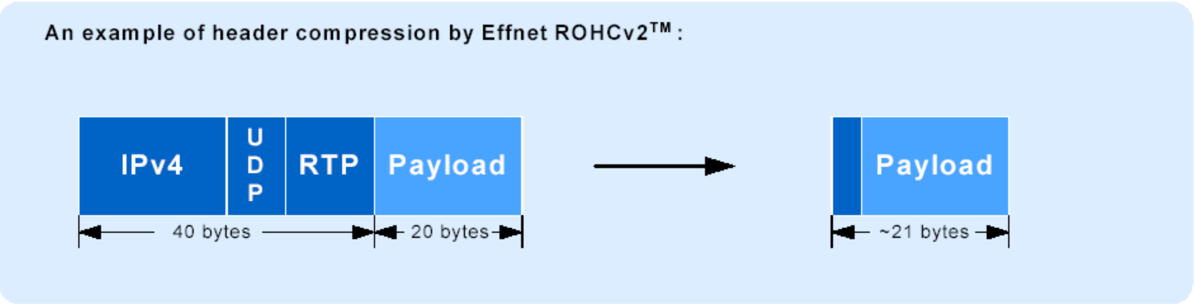
Mobility is the cornerstone of the cellular networks but supporting it efficiently is a tricky business. As the cellular network architectures have evolved, the integration point of ROHC in system nodes has moved closer towards mobile terminals for various reasons but has lead to a problem of handling reordering of packets during mobility. Effnet ROHCv2™ addresses this concern very efficiently while providing high compression efficiency and robustness.

The following parts of RFC 5225 are implemented and apply to all profiles unless stated otherwise:

- All profiles: 0x0000 (UNCOMPRESSED), 0x0101 (RTP), 0x0102 (UDP), 0x0103 (ESP) and 0x0104 (IP) are supported.
- All the compressor and decompressor states and the state transitions.
- All modes and mode transitions: Unidirectional (U-mode), Bi-directional Optimistic mode (O-mode).
- Encoding methods : LSB, W-LSB, Scaled RTP Timestamp, Timer-based compression of RTP Timestamp, Offset IP-ID encoding, Self-describing variable-length values
    - Transitions to and from Timer-based compression of RTP Timestamp (profile 1).
- Support for reordering
- Use of CRC for protection of control fields.
- Local repair mechanism.
- Parsing and handling of all ROHC packet types.
- Parsing and handling of all ROHC feedback packets and options.
- Inclusion of feedback data in ROHC packets going in reverse direction (piggyback feedback).
- Compression of both IPv4 and IPv6 headers.
- Dealing with changes in semi-static fields, e.g., TTL, TOS, DF-bit, and RTP payload type, RTP X and P bits (the last three is for profile 0x0101 only).
- Heuristics for detection of IP-ID behavior.
- Dealing with changes in IP-ID behavior.
- Compression of CSRC lists (profile 0x0101).
- Full support for IPv4 and IPv6 with extension headers in static, dynamic and irregular chains.
- Compression of outer IPv4 or IPv6 header.
- Reverse Decompression
- Segmentation & Reassembly.
- Packet size limitation enforcement.

Maintenance and support
Effnet ROHC portfolio for LTE and NR is offered with a full range of support services, including problem reporting, bug fixes, updates, training, consulting and integration services. A team of engineers experienced in standardization of header compression technology, implementation and testing of product portfolio is available for support and consulting services.

Licensing
For licensing of the Effnet ROHC portfolio for LTE and NR, complete or individual products, please contact us at info@effnet.com.



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