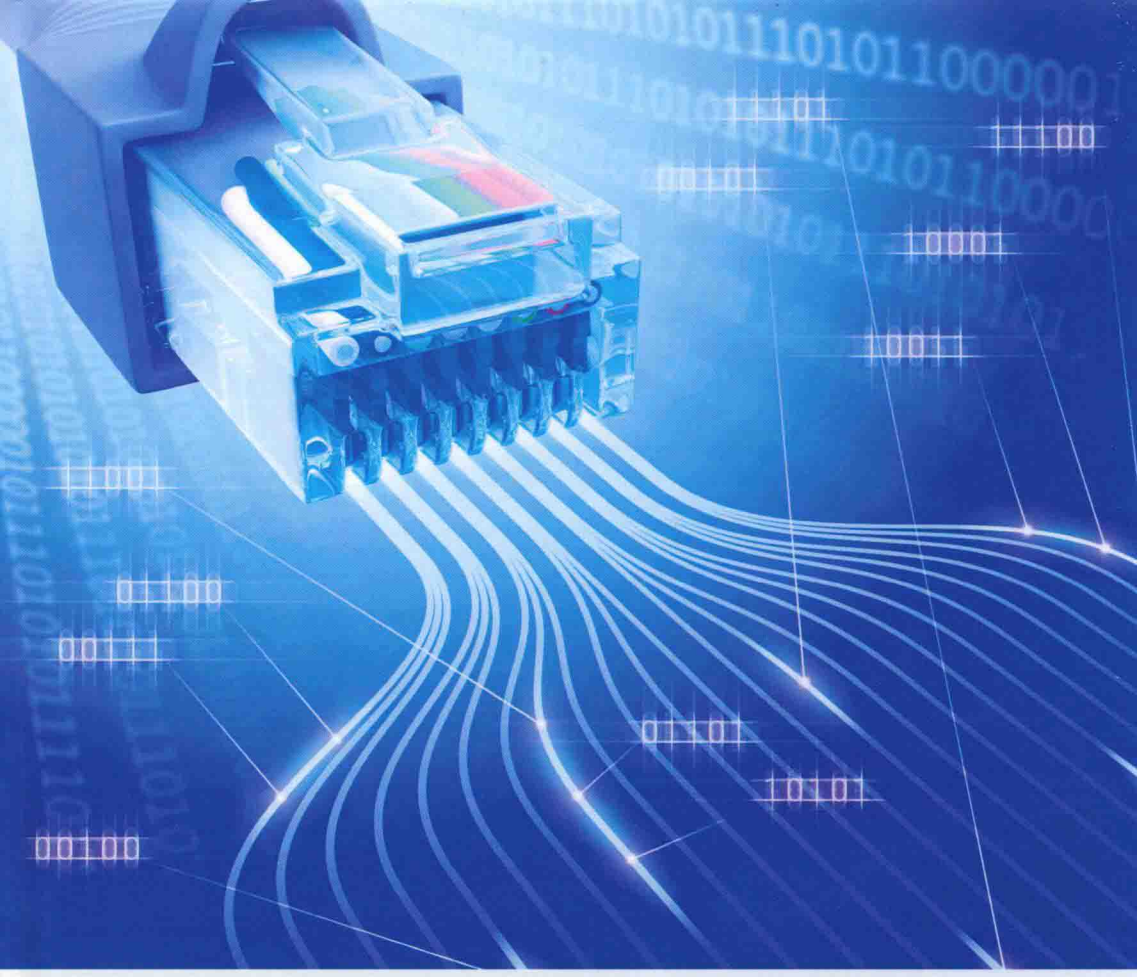

Implementing IP and Ethernet on the 4G Mobile Network

André Perez

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The 4G mobile network allows an IP packet transmitted by a mobile to be transported to its gateway, and reciprocally, using the following networks: MPLS-VPN, VPLS and OTN.

The mechanisms for the implementation of quality of service (QoS) on the EPS, IP, Ethernet and MPLS networks are presented.

The security for the LTE radio interface, the NAS messages and the links of the transport transport (IPSec) are discussed.

Aspects relating to the synchronization of the eNB entities are also detailed, including SyncE (frequency synchronization) and IEEE 1588 (phase and time synchronization) mechanisms.

André Perez is a consultant and a teacher in networks and telecommunications. He works with telecom companies and internet service providers, regarding architecture studies and training on the 4G mobile, IP, Ethernet and MPLS networks.

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Implementing IP and Ethernet on the 4G Mobile Network

Preface

This book deals with the combination of 4G mobile network and transport network of Internet Protocol (IP) packets and Ethernet frames through the analysis of data transfer functions (Chapters 1–6), quality of service (Chapters 7–9), security (Chapters 10–12) and synchronization (Chapters 13–15).

Mobile network

The 4G mobile network allows the flow (IP packet) of the mobile to be transported to its PDN Gateway (PGW) and vice versa.

The flow (IP packet) of the mobile is transported by bearers that are built between the various entities of the 4G mobile network (Figure P.1):

– Data Radio Bearer (DRB) built between the User Equipment (UE) and the evolved Node Base (eNB) station;

– S1 bearer built between eNB and Serving Gateway (SGW) entities;

– S5 bearer built between SGW and PGW entities.

The IP packet, related to the S1 or S5 bearer, contains the IP packet, related to the mobile flow.

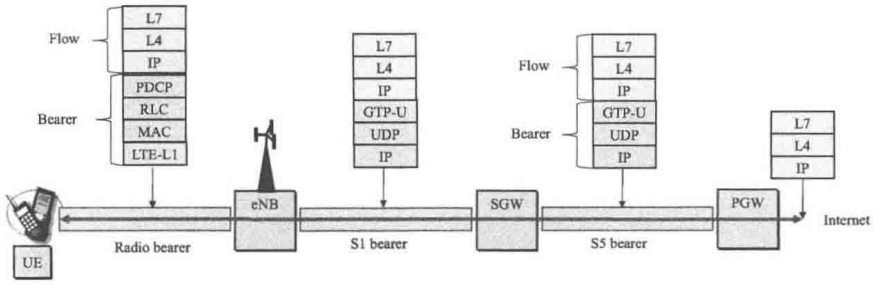

Figure P.1. *Mobile flow transport in a bearer*

Transport network

The transport network of IP packets or Ethernet frames can build a network interconnection for the various entities of the 4G mobile network and consists of the following networks (Figure P.2):

– Multiprotocol Label Switching-Virtual Private Network (MPLS-VPN) allows us to build an IP network to interconnect different entities of the 4G mobile core network: Mobility Management Entity (MME), SGW, PGW, Home Subscriber Server (HSS) and Policy and Charging Rule Function (PCRF);

– Virtual Private LAN Service (VPLS) allows us to build an Ethernet network for interconnection of eNB entities to the 4G mobile core network (MME, SGW);

– Optical Transport Network (OTN) is a transmission network over optical fiber of Ethernet frames for interconnection over long distances of the various entities Provider Edge (PE) and Provider (P) of the MPLS-VPN and VPLS networks.

S1 bearer transport

The transport of IP packets, related to S1 bearer, is provided by Ethernet frames in the VPLS network between the eNB entity and the R1 router, then by Ethernet frames in the LAN1 network between the R1 router and the SGW entity (Figure P.3).

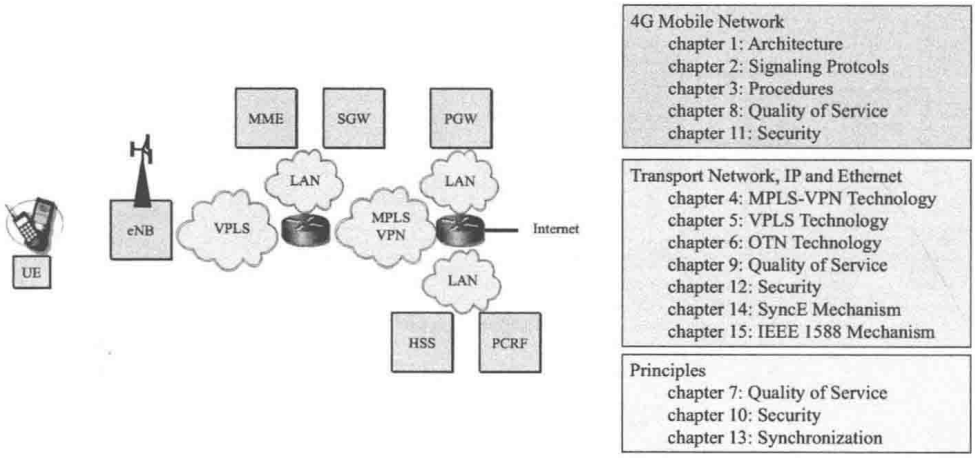

Figure P.2. *4G mobile network and transport network*

Ethernet frames into the VPLS network are switched by the PE entities and transported between the PE entities in virtual circuits, the P entity ensuring the label switching.

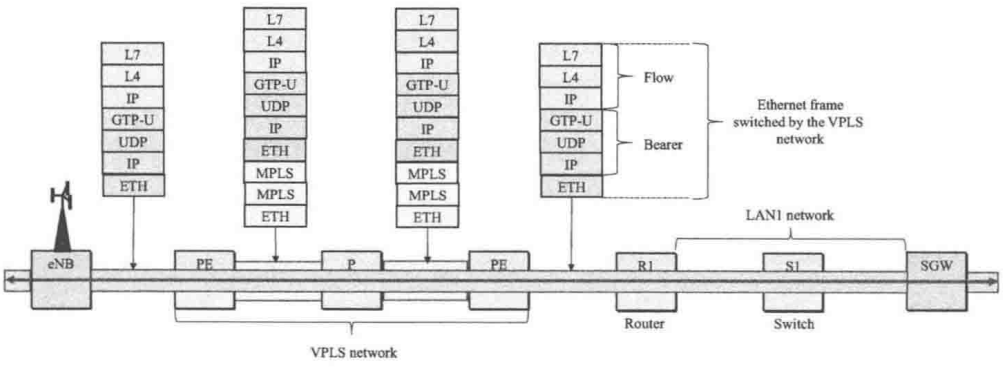

Figure P.3. *S1 bearer transport*

S5 bearer transport

The IP packets, related to the S5 bearer, are transported by Ethernet frames in the LAN1 network, between the SGW entity and the R1 router, and by Ethernet frames in the LAN2 network, between the R2 router and the PGW entity (Figure P.4).

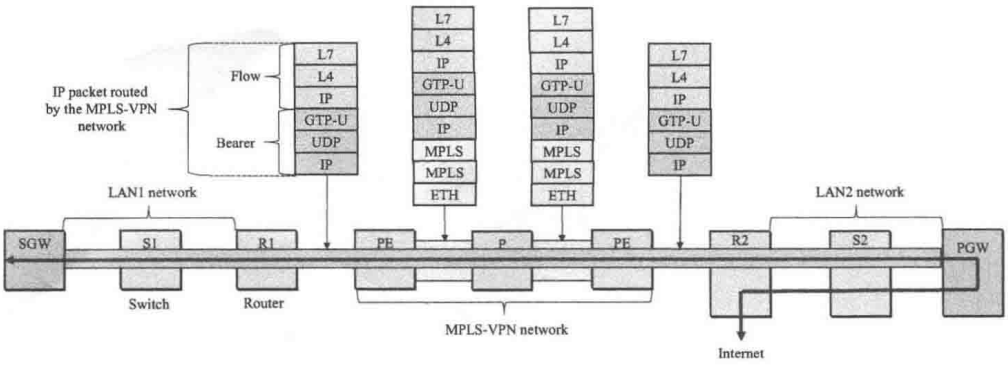

Figure P.4. *S5 bearer transport*

The IP packets, related to the S5 bearer, are routed by the R1 router, PE entities of the MPLS-VPN network and R2 router.

The IP packets into the MPLS-VPN network are transported between PE entities in virtual circuits, the entity P ensuring the label switching.

The IP packet, related to the mobile flow, is routed by the PGW entity, transported by Ethernet frames to the R2 router, and then routed by the R2 router to access the Internet network.

OTN network

OTN provides the constitution of the following components:

– Optical Channel (OCh) based on data from PE or P entities of the MPLS-VPN or VPLS networks;

– Optical Multiplex Section (OMS) performing the wavelength-division multiplexing of different OChs;

– Optical Transmission Section (OTS) of the wavelength multiplex (Figure P.5).

The structure of the OTN depends on the network topology and includes Optical Line Terminal for constitution of linear links, Optical Add-Drop Multiplexer (OADM) for constitution of linear or ring network or Optical Cross-Connect (OXC) for constitution of mesh networks.

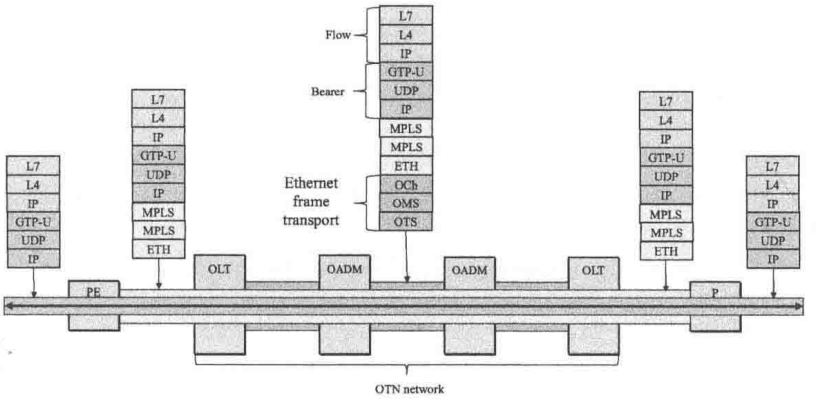

Figure P.5. *Optical transport network*

Quality of service

Flows and bearers are grouped into classes of service identified by the following parameters:

– QoS Class Identifier (QCI) for the bearers DRB, S1 and S5;

– DiffServ Code Point (DSCP) for the IP packets;

– Priority Code Point (PCP) for Ethernet frames;

– EXP or Traffic Class (TC) for labeled packets or frames.

The quality of service comprises on applying to each data structure the behavior (congestion avoidance, scheduling) based on the value of the identifier.

The value of the QCI parameter applied to a data structure is defined by the 4G mobile network. The value of other parameters is obtained by mapping from the QCI parameter.

Security

Security in 4G mobile network

The security architecture implemented in the 4G mobile network is on the attainment of the following:

– mutual authentication of the 4G network and the mobile;

– security of the signaling messages Non-Access Stratum (NAS) exchanged between the mobile and the MME entity. The security regards the integrity control and the encryption of the messages;

– security of the radio interface Long-Term Evolution-Uu (LTE-Uu) between the mobile and the eNB entity. The security regards, first, the integrity control and the encryption of the messages Radio Resource Control (RRC) and, second, the encryption of IP packets of the user plane.

Bearer protection

IP Security mechanism implements protection of S1 and S5 bearers between the following entities (Figure P.6):

– eNB entity and SEG1 (Security Gateway) entity located in the LAN1 network for S1 bearer;

– SEG1 and SEG2 entities located, respectively, in the LAN1 and LAN2 networks for S5 bearer.

The IP packet, related to the mobile flow, is protected at the Packet Data Convergence Protocol layer on the radio interface LTE-Uu (Figure P.6).

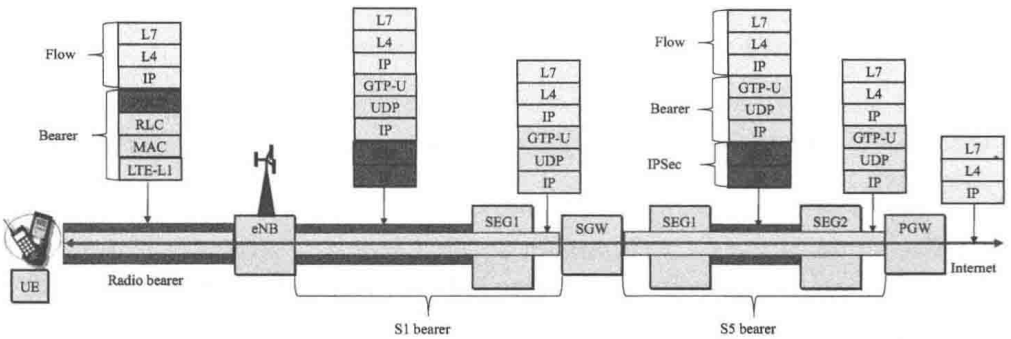

Figure P.6. *Bearer protection. For a color version of this figure, see www.iste.co.uk/perez/4gmobile.zip*

Synchronization

The different entities of the mobile network, with the exception of the eNB entity and the transport network, require no synchronization to implement the data transfer.

The radio interface of eNB entities must be synchronized in frequency to ensure the change-of cells during the session (handover) for both modes of operation, the Frequency Division Duplex (FDD) and Time Division Duplex (TDD).

For the TDD mode, time synchronization is required to synchronize the time of transmission and reception of eNB entities.

The interference management between eNB entities, based on time sharing of the radio resource, also requires time synchronization of the eNB entities.

The method based on a synchronous physical layer, implemented by the Synchronous Ethernet mechanism (SyncE), is a method that suits frequency synchronization.

The method based on packets used in bidirectional mode, implemented by the IEEE 1588 mechanism, allows time and frequency synchronization.

List of Abbreviations

A

AAA	*Authenticate and Authorize Answer*
AAR	*Authenticate and Authorize Request*
AC	*Attachment Circuit*
AES	*Advanced Encryption Standard*
AF	*Application Function*
AF	*Assured Forwarding*
AH	*Authentication Header*
AIA	*Authentication-Information-Answer*
AIR	*Authentication-Information-Request*
AKA	*Authentication and Key Agreement*
AM	*Acknowledged Mode*
AMBR	*Aggregate Maximum Bit Rate*
AMR	*Adaptive Multi-Rate*
AMR WB	*AMR Wide Band*
AP	*Application Part*
APN	*Access Point Name*
APS	*Automatic Protection Switching*

ARP	*Allocation and Retention Priority*
ARQ	*Automatic Repeat request*
AS	*Autonomous System*
ASA	*Abort-Session-Answer*
ASR	*Abort-Session-Request*
AUTN	*Authentication Network*

B

BA	*Behavior Aggregate*
BC	*Boundary Clock*
BDI	*Backward Defect Indication*
BDI-O	*Backward Defect Indication – Overhead*
BDI-P	*Backward Defect Indication – Payload*
BEI	*Backward Error Indication*
BIAE	*Backward Incoming Alignment Error*
BIP-8	*Bit Interleaved Parity*
BMCA	*Best Master Clock Algorithm*

C

CA	*Certificate Authority*
CAC	*Connection Admission Control*
CBP	*Constrained Baseline Profile*
CBS	*Committed Burst Size*
CS/CB	*Coordinated Scheduling / Beamforming*
CCA	*Credit-Control-Answer*
CCR	*Credit-Control-Request*
CE	*Customer Edge*