Traffic offload technology has been attracting attention in recent years due to efforts made to improve revenues and reduce costs by efficiently handling increases in mobile traffic from mobile network operators as a means of reducing operating costs and improving user experiences. Mobile operators can reduce traffic traversing mobile core networks through offload technology and end-users can obtain benefits from reducing the round-trip time (RTT) to achieve better user experiences.

Traffic offloading is a technology to veer traffic from the U-plane directly to the Internet from long term evolution (LTE) base stations (eNBs). Traffic offload in NEC's cloud centric approach to next-generation mobile network solutions is very important as it offers a competitive solution with strong differentiators to mobile operators.

This white paper presents the benefits of traffic offloading as part of NEC's cloud centric approach and provides an overview of NEC's development and research activities to ensure the future cloud centric mobile operator networks.

Benefits

a) Mobile Operators

Mobile operators can reduce traffic traversing mobile core networks by means of traffic offloading. As a result, it is unnecessary for mobile operators to deploy additional packet gateways (called local-GWs or L-GWs) to handle excessive traffic, which can decrease the mobile operators’ total cost of ownership (TCO).

Mobile operators can gain two additional benefits by using mobile offload technology. The first is that smartphones can connect directly to servers without going through mobile core networks. Therefore, user experiences can be improved. RTTs or delays specifically decrease and throughput increases. The second is that mobile operators can offer CDN services that have these network characteristics with differentiators that have shorter delays than those of other operators.

b) End-users

RTTs can be expected to reduce and consequently throughput, due to the transmission control protocol (TCP)
(TCP), increases from the end-users’ viewpoint. These can improve user experiences.

c) Service Providers

Reduced RTTs and increased TCP throughput can be expected by using storage in mobile backhaul networks and providers can offer "fact access" to end-users as premium services to obtain extra revenues from the service providers’ viewpoint.

Additionally, service providers can offer very rich and geographical oriented services by using storage in eNBS due to the short delay network characteristics offered by mobile traffic offload technology.

3GPP Standard

a) Current standard Status

There are two kinds of technologies standardized in 3GPP. These are LIPA (Local IP Access) and SIPTO (Selected IP Traffic Offload). Packet traffic using LIPA and SIPTO that previously traversed mobile cores now directly gets routed to the destinations without traversing mobile core network.

The basic traffic offload features have already got standardized in 3GPP Release 10 – 12. But enhanced features such as UE mobility remains for further investigation and the study continues in 3GPP. In Table 1, the traffic offload architectures standardized in 3GPP are summarized.

<table>
<thead>
<tr>
<th>L-GW location</th>
<th>L-GW is collocated with eNB</th>
<th>L-GW is separate from eNB</th>
</tr>
</thead>
<tbody>
<tr>
<td>Offload From</td>
<td>LAN</td>
<td>Enterprise</td>
</tr>
<tr>
<td>Internet</td>
<td>SIPTO@LN w/ L-GW</td>
<td></td>
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<tr>
<td></td>
<td>collocated with HeNB</td>
<td></td>
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<td></td>
<td>(release 12)</td>
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<tr>
<td>LAN</td>
<td>LIPA</td>
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<td></td>
<td>(release 10)</td>
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</table>

Table 1 Typical Use Case

b) Architecture classification

In the followings, the each offload architecture standardized in 3GPP is briefly explained.

1) LIPA (release 10)

“Local IP Access” is the architecture that HeNB and a Local GW (L-GW) are in the residential/enterprise IP network and can be achieved using a L-GW collocated with the HeNB. The LIPA function enables an UE via a HeNB to access other IP capable entities in the same residential/enterprise IP network without the user plane traversing the mobile operator’s network except HeNB subsystem. In LIPA network, the connection to the local IP capable entities is established by the UEs requesting a new PDN connection to an APN for which LIPA is permitted, and by the network selecting the L-GW associated with the HeNB.

2) SIPTO at the Local Network with L-GW function collocated with the (H)eNB (release 12)

“SIPTO at the Local Network with L-GW function collocated with the (H)eNB” is also the architecture that (H)eNB and a L-GW are in the residential/enterprise IP network and also assumes a L-GW collocated with the (H)eNB. This SIPTO at the Local Network function can be achieved by selecting a L-GW function collocated with the (H)eNB and this function enables an UE to access a defined IP network (e.g. the Internet) directly from the residential/enterprise IP network without the user plane traversing the mobile operator’s network.

The PDN GW (or L-GW) selection function uses the L-GW address proposed by (H)eNB in the S1-AP message, instead of DNS interrogation. In the current specification (Release 12), the UE mobility between (H)eNB is not supported.

3) SIPTO above RAN (release 10)

“SIPTO above RAN” is the architecture that assumes both (H)eNB and a L-GW (or LP-GW) in the mobile operator network.

The SIPTO function enables a mobile operator to offload certain types of traffic at a L-GW close to the (H)eNB that UE attaches. SIPTO can be achieved by selecting a L-GW (or LP-GW) that is geographically/topologically close to a UE’s point of attachment. To. In order to select a set of appropriate GW (S-GW and P-GW) based on geographical/topological proximity to UE, the GW selection function specified in TS 29.303 uses the (H)eNB that UE attaches.

Figure 2 LIPA, SIPTO@LN w/ L-GW function collocated with the (H)eNB

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4) SIPTO@LN (w/ standalone GW (with S-GW and L-GW collocated)) (release 12)

"SIPTO@LN w/ standalone GW " is the architecture that HeNB and a L-GW are in the residential/ enterprise IP network but a L-GW and the HeNBs can be the separate nodes.

This SIPTO at the Local Network function enables an UE connected via a (H)eNB to access a defined IP network (e.g. the Internet) directly without the user plane traversing the mobile operator’s network.

**Figure 3 SIPTO above RAN**

4) SIPTO@LN (w/ standalone GW (with S-GW and L-GW collocated)) (release 12)

"SIPTO@LN w/ standalone GW " is the architecture that HeNB and a L-GW are in the residential/ enterprise IP network but a L-GW and the HeNBs can be the separate nodes.

This SIPTO at the Local Network function enables an UE connected via a (H)eNB to access a defined IP network (e.g. the Internet) directly without the user plane traversing the mobile operator’s network.

**Figure 4 SIPTO@LN (w/ standalone GW (with S-GW and L-GW collocated))**

**NEC’s traffic offload Solution**

The newly developed NEC’s traffic offload solution is based on “SIPTO at the Local Network with L-GW function collocated with the eNB” which is defined in 3GPP Release12.

In this SIPTO solution specified in 3GPP Release 12, the UE mobility function in SIPTO area and the charging function are not supported and remain for the future investigation, since this solution is targeted to deploy in the private local network.

The detail explanations of these two issues are in the followings.

**Routing issues**

IPsec headers and GTP tunnel headers of packets have generally been removed at L-GWs located in mobile cores in mobile networks and these packets are sent to the Internet. However, packets from the Internet are routed to L-GWs that upward 'request' packets pass through. This means communication between servers and UEs cannot be disconnected wherever UEs move. These kinds of L-GWs are called 'anchor nodes' within the context of IP mobility and must look at one logical node or one logical IP address without any changes.

When L-GWs are installed close to or inside eNBs, there are multiple anchors in mobile networks. Thus, if UEs in communication do handovers between L-GWs, and send packets using new L-GWs, they look to corresponding servers as to whether there are multiple IP addresses for L-GWs and the communication established between them cannot continue.

**Charging issue**

Charging in mobile networks is generally done by counting the number of packets users have sent.

Packet count functions in normal mobile core networks, meaning those without traffic offloads, are installed outside packet gateways (P-GWs) to charge users. If traffic is offloaded around eNBs and does not traverse P-GWs in mobile cores, mobile operators cannot count packets, meaning there is no charging function.

Packet count functions are usually mission-critical and cost too much. Consequently, it is still reasonable to establish traffic-offload-enabled eNBs without packet count functions. However, lack of charging functions is a disadvantage when introducing traffic offloads.

However, it is necessary to support these two functions if it is considered to introduce this NEC’s solution also to the public network. In order to meet Mobile Operator’s demand to resolve above issues, it is considered to introduce “packet-countable” and “dynamically route changeable” router/switch just above the L-GW close to eNBs. If the introduced routers are capable to differentiate each IP flow, mobile operators can charge users per IP flows.

NEC’s offload solution is compliant to the Rel12 SIPTO and also includes solutions to the limitation of rel12.

NEC’s traffic offload solution offers three main advantages to mobile operators and end users.
1) QoE improvements
Packets for UEs do not have to traverse "normal" routes via L-GWs in mobile cores by deploying L-GWs inside or just outside eNBs. This decreases the delay between servers on the Internet and UEs and increases TCP throughput. User experiences can also be expected to improve.

2) Efficient use of mobile backhaul resources.
Mobile operators can reduce redundant routes making the routes between servers and UEs change dynamically depending on UEs' moves by using "dynamically route changeable" routers/switches.

Mobile operators can also use mobile network resources much more effectively by distributively handling U-plane traffic without L-GWs in mobile cores.

Additionally, no GTP tunnels or IPSec tunnels are needed in NEC’s traffic offload architecture; this enables backhaul bandwidth to be reduced by approximately 25% according to the NGMN Alliance [5].

3) TCO reduction
Using mobile network resources more effectively means that mobile operators do not have to increase the number of mobile core nodes (e.g., L-GWs and routers) depending on the increase in traffic at the same rate as before, as was mentioned in 2). Also reducing the rate of increase in mobile core nodes means that maintenance costs are reduced. These lead to reducing mobile operators' TCO.

Future enhancements

Integrating traffic offload functions into eNBs means that standard Internet protocols are used just after eNBs to communicate with servers on the Internet. However, cache technology has long been one of the most effective ways of reducing traffic. Cache technology is normally used on the Internet but it cannot be used in mobile networks because packets are encrypted. Mobile operators can therefore use cache technology just outside eNBs in NEC's traffic offload solution by integrating traffic offload functions into eNBs.

For example, it is very effective to use cache technology in situations where many people simultaneously want to access the same content as they do at sports matches such as soccer or baseball games or live music events held in large stadiums.

Therefore, NEC has been developing and has combined a traffic offload solution and a cache optimisation solution to dynamically reduce traffic in mobile networks and reduce the load imposed on the content delivery servers of service providers (like those for stadiums). Mobile operators with this kind of solution can expect to improve customer satisfaction and can also provide differentiators to other mobile operators.

Conclusion
The traffic offload solution is one of the best solutions to increased traffic due to the rapid spread of smartphones. NEC's traffic offload solution integrated into eNBs can reduce RTTs, improve user experiences, effectively use mobile network resources, and reduce TCO.

Mobile operators can expect to improve customer satisfaction with this technology and they can offer differentiated services to other mobile operators.

As the number of mobile subscribers has saturated in developed countries, differentiators will play more important roles when mobile operators are selected by end users.

References
[4] 3GPP TR 23.859 “LIPA Mobility and SIPTO at the Local Network (LIMONET)”

Acronyms
3GPP 3rd Generation Partnership Project
LTE Long Term Evolution
SIPTO Selected IP Traffic Offload
LIPA Local IP Access
UE User Equipment
HeNB Home eNB

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