A Storm is Brewing – an LTE Signaling Storm

A Whitepaper

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Abstract: We have all heard about the "signaling storm" and how Diameter signaling traffic can potentially choke the network. The always-on, data-centric nature of devices in the 4G network results in an explosion in the volume of data in the user plane as well as an explosion in the volume of the messages in the control plane. The network architecture of the mobile core has evolved to be more complex with many more elements and interfaces added in each release and the signaling method has evolved from SS7 to Diameter. The user device has evolved with more intelligence and applications resulting in many new events requiring interaction with the mobile core and, of course, the number of devices is growing rapidly. This paper is the first in a series of papers dealing with LTE signaling traffic.

Introduction

In this whitepaper we investigate the much publicized explosion of Diameter signaling in 4G LTE and VoLTE networks. We will look at the sources of increased signaling traffic, both within the network as well as the devices themselves, and the exploding number of applications. Subsequent whitepapers in this series will quantify the amount of signaling traffic using a model developed by Diametriq and then identifies the control plane hot spots.

Let's Start with the Devices

The subscriber devices themselves contribute to the signaling storm. First the sheer number of smart devices is exploding. Shipments of smartphones have exceeded the number of feature phone shipments in most major markets, including China, the US and Europe, for over a year. Globally, the total number of smartphones is expected to exceed the number of active feature phones in 2013. But the key fact is that smartphones and tablets generate more signaling messages than traditional feature phones. Let's examine why.

First, smartphones are "always-on" devices so they typically automatically attach to the network, unlike a feature phone that only does so when the subscriber initiates a data service. Each attach generates signaling traffic. Second, in order to conserve battery life, the smartphone will detach from the wireless connection after a short period of inactivity. This is known as "fast dormancy." The device will reattach when data service is used. The continual attach/reattach from a large number of smart devices generates considerable signaling traffic.

Then there are the applications themselves. Unlike a feature phone with limited use of data services, smartphones and tablets host an ever increasing number of applications, each of which produces varying amounts of signaling traffic. We are all familiar with the phrase "There's an app for that." As application usage grows, signaling traffic increases.

Some applications, like instant messaging and social networking, are always-on services that require a "heart beat," regular messages between the client and server to ascertain the status of the subscriber. This continuous attach/detach/reattach further increases the load in the control plane.

There can also be atypical events which can produce large amounts of signaling traffic. If there should be a network problem where service is interrupted, once service is restored there will be a large amount of devices all trying to reestablish a connection automatically and simultaneously. Signaling overload is a distinct possibility in such cases. Another example is an external hacking attack, where the attacker continuously scans IP addresses. Each active smartphone will react creating a storm of signaling traffic.

The 4G Architecture

Then there is the network architecture itself. The "flat" all-IP infrastructure is actually more complex than the hierarchical structure it replaces. Diametriq's earlier whitepaper "The Evolution of Diameter Signaling" depicted how the number of network elements has grown along with the number of interfaces connecting them.

Network Element	2G Voice	2G Data	3G Voice	3G Data	3G MM	4G Data	4G MM
HLR	C, D	Gc, Gr	-	-	-	-	-
EIR	F	G	F	G	-	S13	S13
SCP	CAP	Ge	CAP	Ge	CAP	-	-
HSS	-	-	C, D	Gc, Gr	Gc, Gr Si, Sh, Cx	S6a	S6a, Sh, Cx
PCRF	-	-	-	Gx	Gx, Rx	Gx	Gx, Rx
OCS	-	-	-	Gy	Gy, Ro	Gy	Gy, Ro
OFCS	-	-	-	Gz	Gy, Rf	Gz	Gz, Rf

SS7 Interface → Diameter Interface

Figure 1: Evolution of Interfaces from SS7 to Diameter

The architecture of the 4G mobile core for providing data and voice service is shown in Figure 2. It utilizes Diameter control plane signaling to communicate from the data network elements to the centralized databases of the HSS, EIR, OCS and PCRF.

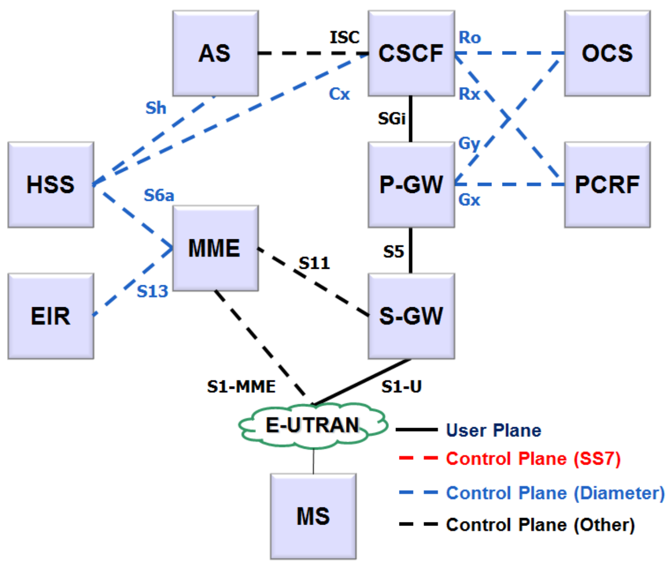

Figure 2: 4G Architecture for Data (LTE) and Voice/Multi-Media (VoLTE)

But an LTE only network is rare. Typically the LTE network must interwork with 3G network elements and applications and perhaps with IMS. Figure 3 shows the additional network elements and additional Diameter interfaces.

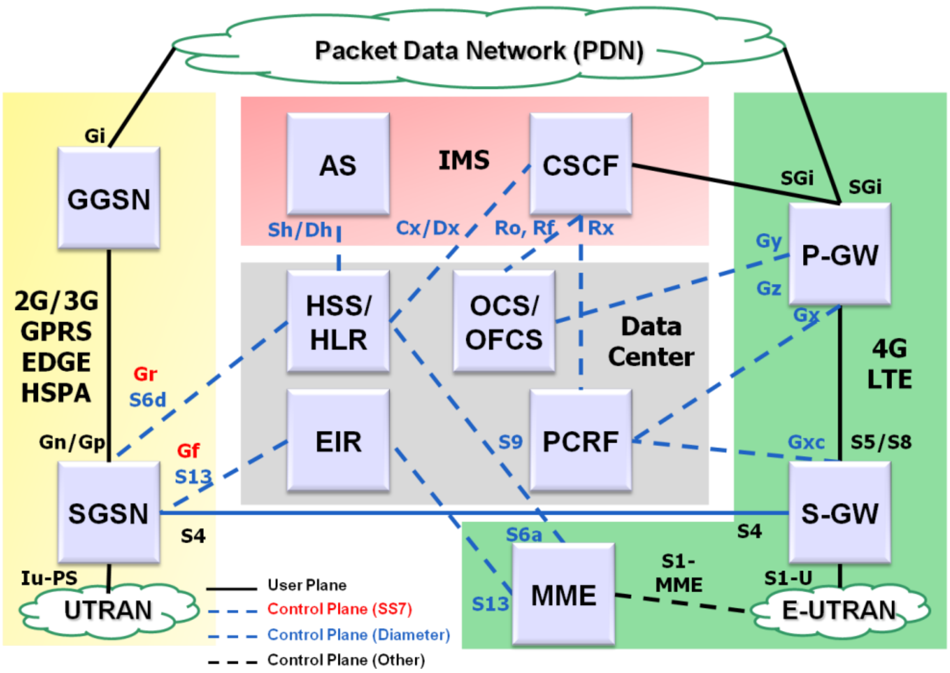

Figure 3: 2G/3G/LTE/IMS Network Architecture

In a real network environment, there can be multiple instances of the network elements due to reasons of scale, redundancy, geographic considerations, mergers/acquisitions and so on. This can create a veritable rat's nest of network element connections.

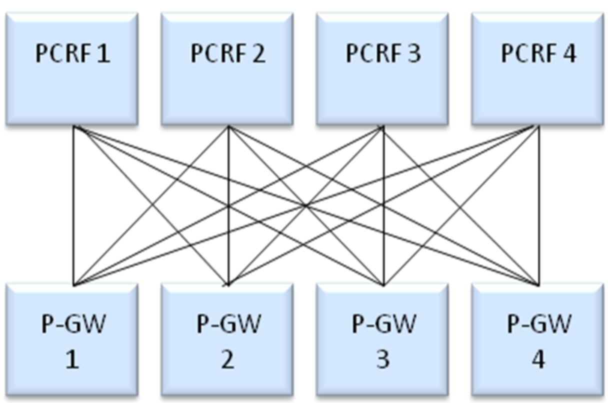

Figure 4: Multiple Instances of Network Elements

Voice over LTE (VoLTE) has just begun to emerge. For a VoLTE session, events in the subscriber device generate Diameter signaling between the various network elements. Such events include attach, detach and tracking area updates that may or may not involve policy modifications or charging updates. The control signaling involves more EPC elements than an ordinary data session or a voice call in a 3G network. Therefore the number of such events is significantly greater in 4G and these events generate an order of magnitude more Diameter signaling than in 2G/3G or IMS. While simplifying the transport layer, VoLTE is expected to further stress the control plane.

Finally, while LTE roaming is still in its infancy, it will soon be as common as 2G/3G roaming. Roaming adds another layer of signaling complexity with additional interfaces to other networks or mediation services. A new network element, the Diameter Edge Agent (DEA) has been defined to provide security across untrusted domains, topology hiding and scalability: more elements, more interfaces, more signaling.

Conclusion

The industry has already recognized the need for careful management of the control plane in LTE networks. The accepted solution is the Diameter Signaling Controller (DSC). The DSC incorporates various functions in the LTE control plane that have been defined by the 3GPP, the GSMA and the IETF. Considering the looming signaling storm, the reliability of mobile service depends on managing control plane traffic. But how much signaling traffic can be expected? At what point does signaling congestion cause network performance issues and outages? Diametriq will be answering these questions in the subsequent whitepapers in this series.

Acronym	Reference	Description
AS/AF	3GPP	Application Server/Function.
CSCF	3GPP	Call Session Control Function
Cx/Dx	3GPP	Interface between CSCF and HSS/SLF.
DEA	GSMA	Diameter Edge Agent.
DRA	3GPP	Diameter Routing Agent.
DRE	Diametriq	Diameter Routing Element.
DSC	General	Diameter Signaling Controller.
EIR	3GPP	Equipment Identity Register.
EPC	3GPP	Evolved Packet Core.
UTRAN/E-UTRAN	3GPP	Universal Terrestrial Radio Access Network - Evolved UTRAN.
Ge	3GPP	Interface between gprsSSF (SGSN) to gsmSCF (SCP)
Gf/Gr	3GPP	Interface between SGSN and EIR/HLR.
GGSN/SGSN	3GPP	Gateway/Serving GPRS Support Node
Gx/Gxc	3GPP	Interface between P-GW/S-GW and PCRF
Gy/Gz	3GPP	Interface between OCS/OFCS and PCEF.
HLR	3GPP	Home Location Register.
HSS	3GPP	Home Subscriber Server
Iu-CS/Iu-PS	3GPP	Interface between the UTRAN and the MSC/SGSN.
MME	3GPP	Mobile Management Entity.
OCS/OCFS	3GPP	On-line/Off-line Charging System.
PCRF	3GPP	Policy and Charging Rules Function.
PDG/ePDG	3GPP	Packet Data Gateway – Evolved PDG
P-GW/S-GW	3GPP	PDN/Serving Gateway.
Ro/Rf	3GPP	Interface between the CSCF and OCS/OFCS.
Rx	3GPP	Interface between the CSCF and PCRF.
S13/S13’	3GPP	Interface between MME/SGSN and EIR.
S6a/S6d	3GPP	Interface between MME/SGSN and HSS.
S9	3GPP	Interface between the H-PCRF and V-PCRF.
SLF	3GPP	Subscription Location Function.
Sh/Si/Dh	3GPP	Interface between the AS/IM-SSF and HSS/SLF.
VoLTE	3GPP	Voice-over-LTE.

About Diametriq:
Diametriq, offering LTE control signaling solutions to meet the needs of LTE network operators, was built on the assets of IntelliNet Technologies, a wireless solutions company founded in 1992. The company’s application enabled Diameter Routing Engine™ (DRE) addresses traffic management, interoperability and service migration issues. The DRE includes a Diameter Routing Agent (DRA), Diameter Edge Agent (DEA), a Subscription Locator Function (SLF) and a Diameter Interworking Function (IWF). For more information, visit www.diametriq.com.