The LTE Data Storm in the Core of Your Network!

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While 4G LTE is the all new rage, setting up an effective, adequately dimensioned LTE network throws up an entire host of challenges to the mobile operator that has to not only manage current users but also cater to upcoming deluge of high-speed data users who are bound to push the network to its limits. It is expected that by year end 2013, the number of smart phones shipped globally will exceed the number of feature phones shipped.

By nature, smart phones are always on, devices with automatic 'attach' unlike feature phones that only attach on user activation of a data session. Topping it all are social networking and Instant Messaging Applications, constantly sending 'heart-beat' messages to indicate status updates to users thus generating significant additional signalling traffic in the network.

In the current scenario, of smart phones and basic LTE network, there is already ample evidence that signalling traffic is bound to grow an order of magnitude greater than expected. Once Voice over LTE (VoLTE) and LTE Roaming scenarios are built-in, the signalling traffic encountered could worsen the situation thus accelerating 'signaling storms' which potentially could bring down vital elements in the control plane or cause 'temporary brown-outs' in the data core. The challenge this scenario is throwing at carrier network architects and mobile operators is the ability to accurately predict and forecast signalling traffic.

To understand just how much of a challenge this could be, we used the LTE Signaling Traffic Calculator, a web based tool developed by Diametriq to project signalling traffic scenarios for various use cases in a LTE network. This document attempts to project several such scenarios in the next few pages.

According to signaling experts at Diametriq, the best way to resolve this issue is to predict signaling traffic by simulating a variety of traffic scenarios on a tool that gives you an indication of message traffic generated at a network element level. The web based tool, called LTE Signaling Traffic Calculator is interactive and allows users to create various use cases to understand if and when there could be congestion in the control plane.

It appears that rampant data growth in the LTE network will be dwarfed by growth in signaling traffic and mobile operators need to spend time to understand loading issues on their core infrastructure. The exponential growth may leave little or no time to fix the network once services are launched and it would be wise to make accurate assessment of control plane capacity and scalability now before it is too late.

About Diametriq:

Diametriq, an innovator in Diameter signaling control technologies, was launched in 2012 to focus on “Smart Signaling” solutions and meeting the ever increasing signaling traffic demands of 4G/LTE networks. Diametriq offers high performance Diameter signaling solutions to meet the needs of LTE wireless operators. The company’s standards compliant Diameter Routing Engine™(DRE) includes a Diameter Routing Agent (DRA), Diameter Edge Agent (DEA), a Subscription Locator Function (SLF) and a Diameter Interworking Function (IWF).

LTE Diameter Traffic Calculator is Diametriq’s tool to forecast signalling traffic and was used for this study.
For more on the company, please visit www.diametriq.com

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The table below summarizes the various scenarios we explored in this study. Signaling traffic projection is made over a five year period – from 2012 to 2016 (both years included). Each scenario assumes certain volume of LTE devices in year 1, growing at a certain rate (as defined in column 2). The number of simultaneous applications running per device is initially 1 but has been varied over the scenarios to show the skew in traffic generated. Mobility is varied between high and medium mobility to understand overall signaling impact.

Scenarios\Parameters	Number of LTE Devices (Million)	Annual Growth Rate of LTE Devices (%)	Number of Simultaneous Apps per Device	Annual Growth Rate of Simultaneous Apps per Device (%)	Average Dormancy (Minute)	Mobility	Prepaid (%)	Policy Enabled (%)	VoLTE Enabled (%)	Annual Growth Rate of VoLTE Enabled (%)	VoLTE BHCA per Subscriber	Annual Growth Rate of VoLTE BHCA per Subscriber (%)
Default	0.5	150	1	20	30	High	100	100	0	25	2	25
I	0.05	200	1	20	30	Medium	97	100	0	25	2	25
II	0.1	200	1	20	30	Medium	97	100	0	25	2	25
III	0.5	300	3	30	30	Medium	97	100	0	25	2	25
IV	1.0	500	4	50	30	Medium	97	100	10	35	2	25

Considering emerging markets such as India, with largely pre-paid subscriber base, the overall user base is tilted heavily in favor of pre-paid markets (thus variations are between 97% - 100% pre-paid). By default all users are policy-enabled in all scenarios but VoLTE (voice over LTE) subscribers are kept low. In most markets, initially LTE is still a pure-data play and only now some form of voice is being tested and in this context, we kept voice subscribers at low levels in year 1 (0% or 10% in year 1, growing at 25% annually from year 2).

VoLTE BHCA (busy hour call attempts per subscriber) is retained at 2 for the first year in all scenarios, growing at about 25% per year for later years.

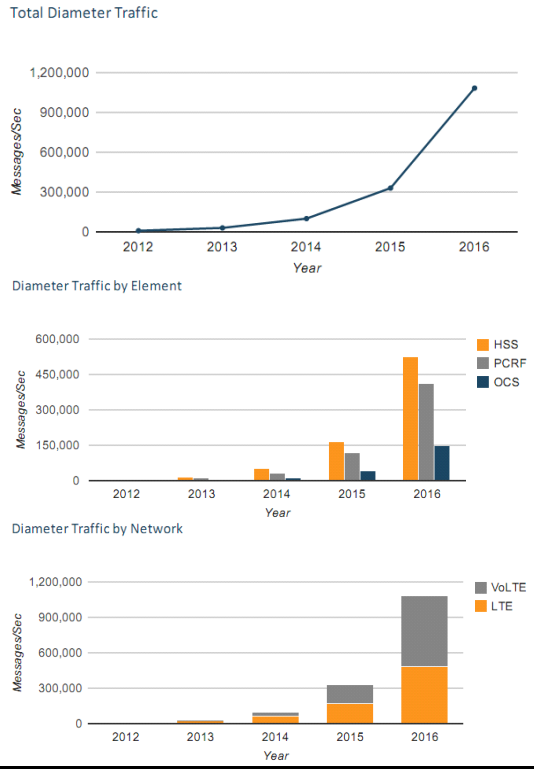
These are fairly normal scenarios and the objective is to observe messaging traffic output to get a view of possible points of congestion in the 4G packet core. The Diametriq tool allows user to try several combinations and enables you to draw your own inferences. These are merely representative samples of the scenarios shown here and you can simulate your own combinations keeping your subscriber base / device and application density in mind.

Scenario 1: Default - Device density starts from 0.5 million in year 1 growing at 150% annually

Parameters\Scenarios	Default
Number of LTE Devices (Million)	0.5
Annual Growth Rate of LTE Devices (%)	150
Number of Simultaneous Apps per Device	1
Annual Growth Rate of Simultaneous Apps per Device (%)	20
Average Dormancy (Minute)	30
Mobility	High
Prepaid (%)	100
Policy Enabled (%)	100
VoLTE Enabled (%)	0
Annual Growth Rate of VoLTE Enabled (%)	25
VoLTE BHCA per Subscriber	2
Annual Growth Rate of VoLTE BHCA per Subscriber (%)	25

Projection Report

	2012	2013	2014	2015	2016
Total Diameter Messages/Sec	8889	30139	100313	330614	1084480
Diameter Messages/Sec in LTE Network	8889	23889	64722	176806	487014
Diameter Messages/Sec in VoLTE Network	0	6250	35590	153809	597466
Diameter Messages/Sec in HSS	5000	16632	53411	168088	523082
Diameter Messages/Sec in PCRF	2778	9861	34531	119734	412032
Diameter Messages/Sec in OCS	1111	3646	12370	42792	149367



In the default scenario, the LTE network carries a nominal 0.5 million devices in first year of launching services with just 1 application running per device. Devices are on high mobility mode and are 100% pre-paid but are not VoLTE enabled at this phase of service launch. By year 2, the device count has gone up by 150% (to 0.75 million) and about 25% of these (about 0.1875 million) are VoLTE enabled.

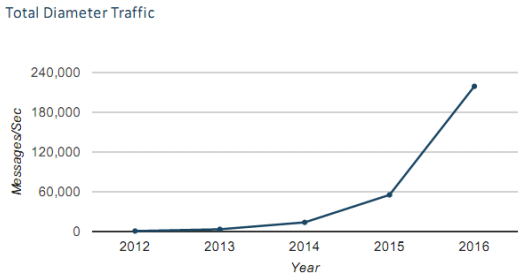
Notice that the total Diameter messages in network per second (sum of Diameter messages in LTE and VoLTE network) has gone up from a mere 8889 messages per second to about 1 million (1,084,480 messages per second) or a whopping 12,200% in five years. This is the order of magnitude growth we are talking about which is a storm in progress. Functional element-wise, the HSS carries the bulk of the signaling load and may need to be enhanced dramatically to sustain the load. OCS (On line Charging server carries a fair burden too and will need upgrades as pre-paid traffic builds up query base to allow fast transactions per session.

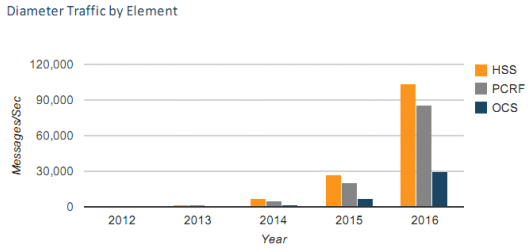
Scenario 2: Device count kept low at 0.05 million devices at service launch growing at 200% per year

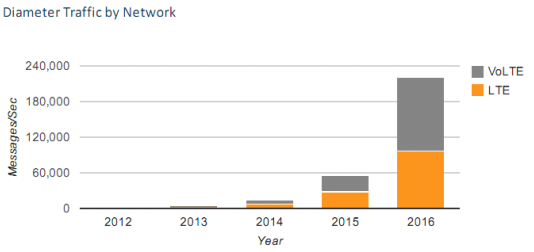
Parameters\Scenarios	I
Number of LTE Devices (Million)	0.05
Annual Growth Rate of LTE Devices (%)	200
Number of Simultaneous Apps per Device	1
Annual Growth Rate of Simultaneous Apps per Device (%)	20
Average Dormancy (Minute)	30
Mobility	Medium
Prepaid (%)	97
Policy Enabled (%)	100
VoLTE Enabled (%)	0
Annual Growth Rate of VoLTE Enabled (%)	25
VoLTE BHCA per Subscriber	2
Annual Growth Rate of VoLTE BHCA per Subscriber (%)	25

Projection Report

	2012	2013	2014	2015	2016
Total Diameter Messages/Sec	830	3437	13892	55408	219449
Diameter Messages/Sec in LTE Network	830	2690	8790	28962	96217
Diameter Messages/Sec in VoLTE Network	0	747	5102	26446	123231
Diameter Messages/Sec in HSS	444	1829	7191	27546	103966
Diameter Messages/Sec in PCRF	278	1183	4973	20690	85439
Diameter Messages/Sec in OCS	108	424	1728	7173	30043







In Scenario 2, a market case is simulated on a very low base of 0.05 million with no voice enabled devices in first year of operation. Device growth is assumed more rapid than default scenario (200% per year) with a marginal drop in subscriber mix (pre-paid versus post-paid) and mobility maintained medium (instead of High mobility in Default scenario).

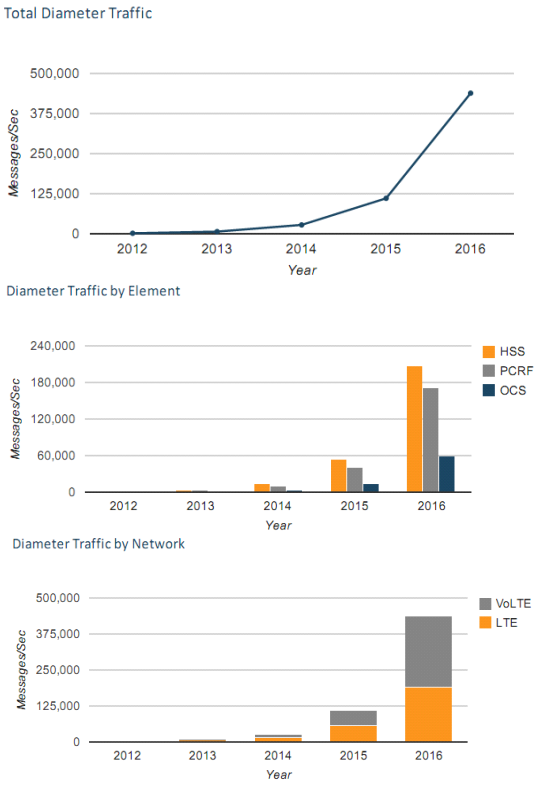
The Diameter messages in VoLTE network rise from zero to a mere 123k messages (0.123 messages /sec) compared to about 600k messages (0.597 million messages / sec in default scenario). The combined Diameter messages in total per second across this configuration of LTE network for the said parameters at the end of 5 years is a mere 0.219 million messages / second. While this represents a 2644% growth in traffic it is still small compared to the default case. This clearly demonstrates that number of active devices is a very big factor driving signaling traffic in LTE networks.

Scenario 3: Moderate density of devices (0.1 million) in year 1 growing to about 1.2 mil by year 5

Parameters\Scenarios	II
Number of LTE Devices (Million)	0.1
Annual Growth Rate of LTE Devices (%)	200
Number of Simultaneous Apps per Device	1
Annual Growth Rate of Simultaneous Apps per Device (%)	20
Average Dormancy (Minute)	30
Mobility	Medium
Prepaid (%)	97
Policy Enabled (%)	100
VoLTE Enabled (%)	0
Annual Growth Rate of VoLTE Enabled (%)	25
VoLTE BHCA per Subscriber	2
Annual Growth Rate of VoLTE BHCA per Subscriber (%)	25

Projection Report

	2012	2013	2014	2015	2016
Total Diameter Messages/Sec	1660	6874	27783	110817	438897
Diameter Messages/Sec in LTE Network	1660	5380	17580	57924	192434
Diameter Messages/Sec in VoLTE Network	0	1494	10203	52893	246463
Diameter Messages/Sec in HSS	889	3658	14383	55091	207933
Diameter Messages/Sec in PCRF	556	2367	9945	41380	170878
Diameter Messages/Sec in OCS	216	849	3456	14345	60087



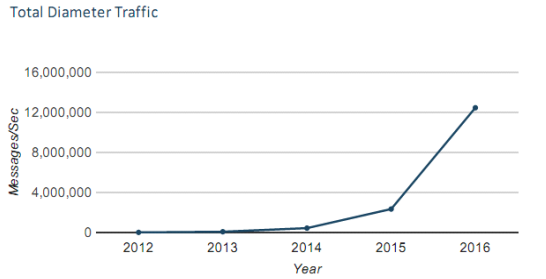
In this Scenario (#3) we have a situation which is somewhat intermediary between default (scenario 1 and scenario 2) with the device count being 0.1 million devices and growing at 200% annually through to year 5. The entire device base is 100% PCRF enabled through the study period and Diametric message density is computed as in earlier cases.

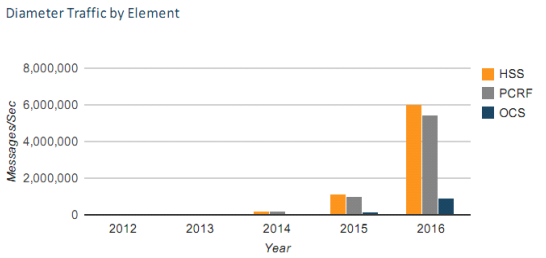
Scenario 4: Device user base starts at 0.5 mil and grows at 300% per year (app density varies)

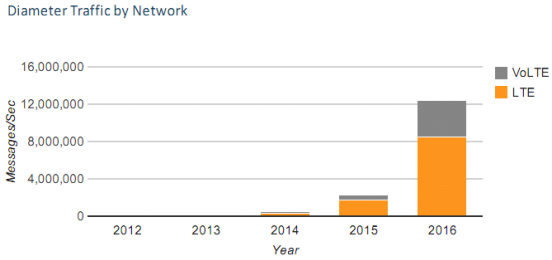
Parameters\Scenarios	III
Number of LTE Devices (Million)	0.5
Annual Growth Rate of LTE Devices (%)	300
Number of Simultaneous Apps per Device	3
Annual Growth Rate of Simultaneous Apps per Device (%)	30
Average Dormancy (Minute)	30
Mobility	Medium
Prepaid (%)	97
Policy Enabled (%)	100
VoLTE Enabled (%)	0
Annual Growth Rate of VoLTE Enabled (%)	25
VoLTE BHCA per Subscriber	2
Annual Growth Rate of VoLTE BHCA per Subscriber (%)	25

Projection Report

	2012	2013	2014	2015	2016
Total Diameter Messages/Sec	14967	81825	440561	2350822	12477805
Diameter Messages/Sec in LTE Network	14967	71867	349867	1723947	8583083
Diameter Messages/Sec in VoLTE Network	0	9958	90694	626875	3894722
Diameter Messages/Sec in HSS	7778	42389	224644	1171651	6056919
Diameter Messages/Sec in PCRF	6111	33778	185200	1009151	5471364
Diameter Messages/Sec in OCS	1078	5658	30717	170019	949522







Here we are simulating a more realistic market scneario where network usage is moderate in year 1 with low device count but as has been seen in some mobile broadband networks, if the service penetration grows at good pace, subscriber base will grow rapidly – in some cases even in excess of the assumed 300% shown here. Here also voice enabled devices begin only in year 2 (2013) and builds up there after.

In this scenario, we expect this LTE network is serving about 40.5 million subscribers in year 5 (2016) of which by year 5.

Scenario 5: Network launch year has 1 mil devices growing at 500% annually for 5 years

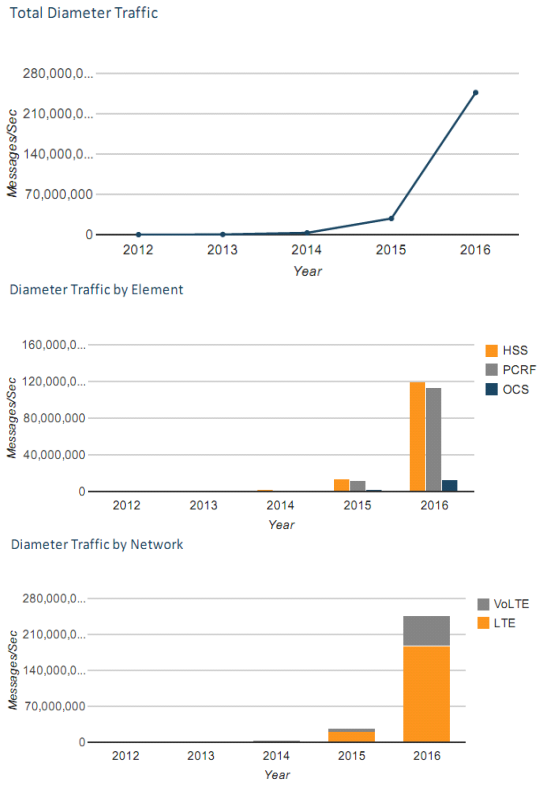
The scenario 5 depicts a LTE network growing at 500% device growth (this does not mean 500% growth in subscriber base as consumers could have more than 1 device per head) annually with at least 10% VoLTE enabled base from year 1. Such a scenario develops an extremely high Diametric message density and could severely cause signaling storms which need major network overhauling to manage.

Going by the Diameter message count, the traffic generated by the network per second by year 5 is about 246 million versus a meagre 3871 messages per second in year 1. Diameter messages in the VoLTE network are still sizeable at about 59 million messages per second (compared to about 1771 messages per second in year 1).

Parameters\Scenarios	IV
Number of LTE Devices (Million)	1.0
Annual Growth Rate of LTE Devices (%)	500
Number of Simultaneous Apps per Device	4
Annual Growth Rate of Simultaneous Apps per Device (%)	50
Average Dormancy (Minute)	30
Mobility	Medium
Prepaid (%)	97
Policy Enabled (%)	100
VoLTE Enabled (%)	10
Annual Growth Rate of VoLTE Enabled (%)	35
VoLTE BHCA per Subscriber	2
Annual Growth Rate of VoLTE BHCA per Subscriber (%)	25

Projection Report

	2012	2013	2014	2015	2016
Total Diameter Messages/Sec	38371	353375	3170600	28073756	246984694
Diameter Messages/Sec in LTE Network	36600	299600	2517600	21585600	187833600
Diameter Messages/Sec in VoLTE Network	1771	53775	653000	6488156	59151094
Diameter Messages/Sec in HSS	19889	181833	1604000	13930125	120346875
Diameter Messages/Sec in PCRF	16111	151333	1392000	12632250	113613750
Diameter Messages/Sec in OCS	2371	20208	174600	1511381	13024069



Conclusion:

Various scnearios can be built to determine the signaling traffic load growth via Diametriq's load traffic calculator. The purpose is to get an idea of how the exponential growth in traffic should be managed and planned and what architecture decisions this could impact. The above scnearios lead us to conclude the following:

1. Device count is pre-eminent driver of signaling load on LTE network
2. VoLTE growth certainly adds to signaling load but it is not a dramatically large factor
3. The HSS and PCRF carry significant signaling load impact as services penetration grows
4. The exponential growth in signaling traffic compared to normal growth in subscriber base is inordinately high and can easily bring well architected networks down on their knees.

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