VoLTE Power Consumption

1. ABSTRACT

Voice is a basic mobile service that generates significant revenue for the operators. Voice over LTE (VoLTE) is a packet voice service that differs from the previous 3G and 2G circuit switched voice and provides increased functionality and performance. This paper compares VoLTE, 3G and 2G voice services and aims to show how the optimization of the VoLTE service makes a difference compared to straightforward or suboptimal solutions. The device platform and its main components; modem and RF, are scrutinized.

2. GLOSSARY

2G 2nd Generation, in this context meaning GSM
3G 3rd Generation, in this context meaning WCDMA
AP Application Processor
CQI Channel Quality Indicator
SR Scheduling Request
SRS Sounding Reference Signal
VoLTE Voice over LTE (based on IMS voice)
UL Uplink
UE User equipment
DL Downlink
HARQ Hybrid ARQ (Automatic Repeat Request)
IMS IP Multimedia Subsystem
DRX Discontinuous RX (reception)
SPS Semi-Persistent Scheduling
DTX Discontinuous TX (transmission)
RTP Real-Time Protocol
RTCP RTP Control Protocol
RMC Renesas Mobile Corporation

3. INTRODUCTION

Voice over LTE (VoLTE) offers basic voice services in the LTE packet network. The previous WCDMA (3G) and GSM (2G) voice services were based on circuit switched networks. In the packet network a new network node which is not used for circuit switched voice, the VoLTE server, is introduced to provide the IMS services. In principle, having a voice service available in all its radio networks (2G, 3G and LTE) enables an operator to balance the traffic load between the different radio systems and to utilize its spectrum asset efficiently.
The UE platform’s VoLTE and video support, i.e. the IMS Protocol stack, audio and video processing is distributed across the various handset processors and this can be done in a number of different ways. It is not a simple task to make an optimized hardware and software architecture. However, proper design and the utilisation of optimisations enabled by LTE can make a big difference to the system level power consumption during packet switched voice calls.

There are three key areas to consider: the LTE radio resources control, the retry mechanism and the RF hardware.

From an LTE radio resources control perspective, the LTE UE needs to adapt to the fact that all UL and DL transmissions are very dynamic and fully controlled by the network scheduler, and the UE has to be able to cope with any allocation scenario. Hence, there is no guarantee for power efficient operation as seen from the UE’s point of view. Due to the fact that the network controls all UL and DL activities as well as configures the relevant parameters for the UE operation, the choice of the LTE radio features and their parameters, as well as scheduling decisions greatly impact the power consumption of VoLTE calls.

In packet based system the HARQ mechanism is used to provide reliable reception whilst still allowing for optimal network capacity.

From the device/modem platform’s radio hardware perspective, the number of supported LTE Bands sets challenges to the antenna and RF subsystem design compared to the previous generation air interfaces (GSM, WCDMA) to achieve good performance, support for all the needed GSM/WCDMA/LTE frequency bands, and still achieve low power consumption and PWB area.

4. ARCHITECTURE

This whitepaper discusses the IMS architecture for the voice and video use cases. It presents an optimized architecture for VoLTE audio processing for audio and video calls that also provides an upgrade path to video processing in video calls and allows power saving when only a voice call is active or the video call is downgraded to audio only.

In a phone platform, the change from circuit switched voice support to packet switched and circuit switched voice, i.e. VoLTE, requires changes in the software architecture to minimize the power consumption. The packet voice introduces an IMS telephony application and the IMS stack to the application processor. Additionally, it also introduces an IP stack and packet voice client to handle the RTP/RTCP protocol and jitter buffer to the modem.

Some other public papers on LTE Telephony and battery life discuss the partitioning options for the IMS Protocol stack and audio processing onto the handset processors. Renesas Mobile thinks that the application processor is a straightforward solution with the least complexity to process the VoLTE audio e.g. with Linux based operating systems and application related restrictions. But we also recognize that there are other more complex solutions which allow for higher potential power saving. The modem processor provides better power saving opportunities for audio, and in most platform architectures the legacy voice call audio handling is done in the modem processor. Thus in practice, when the VoLTE user plane audio handling is implemented in the modem processor, the application processor can enter sleep mode. 

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On the other hand, the Android IMS software architecture is impacted by the Video Telephony application and the need to playback video with the backlight active and, as in most architectures, the video engine is co-located with the Application Processor (AP), there are less opportunities to save power by the distribution of the media software. The video engine is located in the AP domain because video is generally applied to Internet media presentation, eg YouTube®, and also for video recording and playback in the device. If the video engine, display panel hardware and the display memory would be in separate power domains, it would be possible to save power by providing a direct video stream from the modem processor to the video engine.

The power consumption of video & display hardware is potentially so high that having the AP in sleep mode would not make big difference to the power consumption, i.e when video is active, the audio processing may be done either in the AP or the modem. The location of the audio processing with active video is more based on implementation simplicity as having active video nullifies any audio power saving efforts. The Renesas Mobile architecture, implementable on a variety of products, allows flexible partitioning of OEM video telephony for cellular and WIFI connectivity.

In Figure 1-1, an architecture is presented where all IP streams are routed to the IP stack in the AP. This architecture will in practice keep the AP processor running 100% of the VoLTE call time even when the call is voice only.

As seen in Figure 1-2, in an optimized architecture the voice processing is implemented in the modem processor. The architecture split is made so that the processing capability and power consumption are optimised. The VoLTE audio stream is now routed to the IP stack of the Modem processor. In the case that there are no active IP connections to applications in the AP, it may enter sleep mode during a VoLTE call, enabling lower power consumption.
In the case that the IMS call also has a video component, the video RTP/RTCP is routed to the AP. Routing video to the modem would not result in power consumption savings as the AP needs anyhow to be active during the video call. Renesas Mobile’s VoLTE architecture provides a more efficient voice service than the 3G voice as Renesas Mobile supports the optimization of audio routing.

Renesas Mobile simulations and initial measurements show that from a power consumption perspective, VoLTE is more efficient than WCDMA voice (Figure 1-3). In the following the estimated LTE power consumption with two different discontinuous transmission and reception (DRX) values, 40 ms and 20 ms, are compared to a standard WCDMA voice call. The target with VoLTE using 40 ms DRX cycle is to achieve 40-50% of the power needed for 3G voice and with VoLTE with 20 ms DRX cycle 50-60 % of the power needed for 3G: These values make a number of assumptions:

- That the network radio optimizations are in place
- That the phone design mechanical issues such as antenna placement and design in the final phone integration have been successful
- And that the audio routing optimization in the platform is in use.
5. MODEM AND ALGORITHMS

LTE is designed as a dedicated packet based system and does not have Circuit Switched (CS) channels which are most suitable for speech scenarios like VoLTE. When CS voice call types of scenarios are considered, the LTE system suffers from the fact that IP packet data traffic exposes the system to a completely different behavior. IP packet data scenarios exploit a more dynamic burst type of behavior where burst sizes and intervals may vary significantly, whereas in CS speech the traffic is much more predictable with respect to the burst size and interval.

In LTE, dynamic scheduling is used, which means that transport blocks on the physical level are signaled to the UE on a TB by TB basis via the control channel intended for this purpose (the PDCCH). This dynamic type of scheduling is very suited for packet orientated traffic. It can also be used for speech call type of data but it is not very efficient in term of network capacity since its causes a huge signaling load (to allocated uplink and downlink resources) when the number of UEs in voice calls in the cell is high and hence degrades the network capacity. Therefore, the Semi-Persistent scheduling (SPS) feature has been defined in the LTE standards. SPS is intended to compensate for the absence of CS channels, by allowing VoLTE call to be done a more efficient way. SPS can be used to define a semi–static radio resource allocation (comparable to a kind of a CS channel without the signaling overhead), which will bring more network capacity plus it offers the UE more predictability of the transport block allocations.

Since all the UL and DL transmissions are very dynamic and fully controlled by the network scheduler, the UE has to be able to cope with any scenario. Hence the UE implementation alone cannot guarantee power efficient operation. Therefore the network greatly impacts the power consumption of VoLTE calls as it controls all the UL

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and DL activities as well as configures the relevant parameters for the UE operation, the choice of the LTE radio features and their parameters, as well as scheduling decisions. In LTE, the Hybrid Automatic Repeat Request (HARQ) mechanism is used for providing reliable data transmission and reception whilst still allowing for optimal network capacity. The downside of HARQ is that it has a negative impact on the system if HARQ activity starts to get too high on DRX configurations with short DRX cycles – like the ones most suited for VoLTE scenarios. In other words, too many HARQ retransmissions can keep the UE in the active state for prolonged periods during the VoLTE call.

5.1 Impact of network configuration

The network configuration has a significant impact on the UE power consumption, especially in the short DRX configurations typically used in VoLTE (speech call). In order to minimize the UE power consumption in VoLTE, the network can, for example:

- Align UL and DL activities so that the UL transmissions are located where the DL allocation are scheduled so that the UE does not have to stay active solely for reception or transmission, but can do both while active.
- Align the data transmissions and the CQI reporting period so that the CQI report can be sent with the DL data ACK and thereby minimize the UE active time due.
- Locate the VoLTE data UL and DL allocations shortly after the SR occasions so that the UE does not have to be active for longer time than absolutely necessary in case it needs to send SR to get and UL grant. For uplink VoLTE data, also SR masking can be used with SPS to eliminate the need for the UE to transmit SR to request uplink resources (which have already been reserved via the SPS).
- Keep the Block Error Rate (BLER) at a reasonable low level (with conservative choice of modulation and coding scheme) to avoid to extensive HARQ activity as HARQ retransmissions extend the UE’s active time significantly.
- Avoid extensive usage of SRS and align the UE SRS transmissions with the modem active time
- Use DRX cycle, onDurationTimer and drx-InactivityTimer parameters that fit with the nature of the data being sent (the DRX cycle length should be maximized, and the activity timers minimised).

In terms of VoLTE the most important parameters are the DRX cycle, the onDurationTimer and drx-InactivityTimer parameters (defined in 3GPP 36.331)

The DRX cycle should be set to align with the voice packet rate or its multiple (e.g. 20, or preferably 40 ms bundling two voice packets) and the onDurationTimer and drx-InactivityTimer parameters shall be set to minimal values (1 or 2 sub-frame) to fit best to the traffic pattern of VoLTE having fixed packet intervals.

From UE point of view, the optimal VoLTE configuration can be achieved by using dynamic scheduling as well as SPS.
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5.2 Renesas Mobile modem activity in VoLTE configurations

In case of VoLTE, Renesas Mobile has estimated that if the network configures the UE in a power optimal way, the modem will typically be active for 35% of the time when configured with a 40 ms DRX cycle, and 65% of the time if the UE is configured with a 20 ms DRX cycle.

During the time where the modem is not active, it will use the opportunity to power off the hardware and go to inactive or sleep state in order to reduce its power consumption.

6. RADIO HARDWARE

When the RF subsystem power consumption in LTE mode is compared to the consumption in WCDMA mode, the consumption in LTE mode is higher. To simplify, this is due to the higher supported datarates, and larger number of supported frequency bands. The LTE RF subsystem needs to support more frequency bands compared to 3G or GSM. By comparison, UMTS/HSPA+ currently utilizes about ten frequency bands worldwide. For LTE there are close to forty bands identified for LTE.

The number of LTE Bands sets challenges to the antenna and RF subsystem design compared to previous generations of radio interface to achieve good performance, support all the needed bands, and still achieve low power consumption and PWB area. In theory, each frequency band requires its own duplexer and power amplifier complemented with the necessary antenna switching components. Hardware can be optimized by using e.g. multimode power amplifiers supporting several bands, but supporting all the possible bands in the same device is not practical. It also should be noted that typically a multimode power amplifier (PA) is less power efficient than a dedicated single band PA. At the moment a typical device supports less than ten LTE bands.

Moreover, LTE enables channel bandwidths from 1.4 MHz to 20MHz, or even to 100 MHz in LTE-Advanced. Especially wide channels are problematic for linearity and current consumption.

Improvements, like carrier aggregation, are being introduced to utilize more bandwidth in the LTE data transfer cases, enabling higher data rates. This also adds complexity for RF subsystems due to two simultaneous carriers either in intra-band or non-contiguous inter-band usage. On the other hand, even if the total power consumption is increased, the higher supported data rate means the power consumption per transferred bit is reducing. Overall, the optimisation for maximising datarates is not easy and requires different means compared to optimising power consumption in low datarate, like VoLTE, applications.

In the VoLTE case, the biggest power savings are enabled by using discontinues reception and transmissions (DRX, DTX), which only keeps the RF active when needed (plus the RF wake-up overhead). On other words, depending of the used parameters, the RF Tx and Rx paths are powered only for a portion of the time.

Figure 1-3 (architecture chapter) compares a chipset platform including the RF subsystem power consumption in different use cases relative to a 3G Voice Call as defined by TS09. It can be seen that LTE mode consumption is much higher compared to 3G if the device is always in connected mode, i.e. Rx and Tx activity is 100%.
The figure 1-3 use cases visualize the impact of DRX with two DRX cycles (20 and 40msec), and with optimistic and pessimistic network parameters. From an RF perspective the Tx power level is 10dBm in all LTE cases, as defined by TS09. It should be noted this is somewhat higher than the average power level compared to the corresponding 3G talk case in TS09 to reflect the different network topologies. This aspect together with mandatory DL MIMO in LTE increases Rx power consumption and requires efficient methods to reduce the power consumption using time domain techniques explained in this white paper.

7. CONCLUSIONS

The Renesas Mobile architecture, implementable on a variety of products, allows flexible partitioning of VoLTE video telephony for cellular and WIFI connectivity for a device manufacturer according to their needs. The platform architecture (APE, modem and RF) and supported radio optimizations offer considerable power savings. Hence, optimised VoLTE can offer battery stand-by time enhancements compared to 3G or other solutions. Renesas mobile has the knowledge on the platforms and their optimisations and has cooperated with leading network vendors in order to exceed the existing 3G voice experience in order to enhance the operators’ VoLTE launches in 2013 and onwards.