Disruptive Analysis

Don't Assume

A critical examination of CSFB as a solution for providing Voice-on-LTE

Independent white paper commissioned by Kineto Wireless

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Introduction

This document is a white paper discussing the viability of the Circuit Switched Fallback (CSFB) approach to delivering voice services on LTE mobile networks. It looks at the limitations of CSFB, positioning it against alternative solutions like VoLGA, VoIMS and Internet VoIP.

It has been prepared by independent technology industry analyst and consulting firm Disruptive Analysis, commissioned by Kineto Wireless. Disruptive Analysis has been a long-term observer of the convergence of voice technologies and wireless IP network, covering Wireless VoIP since 2001 and publishing research reports on topics including VoWLAN, VoIPo3G, IMS-capable handsets and Mobile Broadband. Its clients include a broad array of vendors, operators, regulators, industry associations, investors and Internet companies.

Background to voice-on-LTE

Despite the recent growth of 3G mobile broadband and smartphone appstores, the bulk of cellular industry revenues still come from ordinary telephony. Irrespective of the rapidly-rising volumes of data traffic and the need for more capacity and speed, it is clearly important for operators to retain the ability to deliver a good voice experience, on any new radio network deployment intended for a broad audience.

But unlike previous generations of mobile standards like GSM, LTE does not have dedicated channels for circuit-switched (CS) telephony, instead relying on an end-to-end IP connection from the handset to the core network. Consequently, any form of voice service used on an LTE bearer, by definition, must be some form of VoIP. As far back as 2006 it became obvious that implementing voice telephony was the "elephant in the room" for LTE, but progress on solid and suitable definitions has been glacially-slow. Following a rather panicked flurry of activity, there are now two 3GPP-approved solutions to this problem – VoIMS and CS Fallback - as well as several other non-standardised alternatives.

The ultimate intention is to exploit LTE's lower latency and QoS features to provide comparable (or better) speech services than have been possible on traditional 2G and 3G networks. This mirrors the slow drift towards VoIP in some fixed carrier networks, where broadband voice (VoBB) has been delivered via copper, coaxial or fibre lines in various markets. Some of the voice solutions proposed for LTE can also work for fixed broadband, offering the possibility for converged operators to move towards a single, unified VoIP architecture – potentially reducing costs and enabling new FMC functionality.

However, any upgrade to "full VoIP" on LTE is fraught with complexity, myriad options that need to be chosen among, and protracted timelines for deployment and optimisation. There is a lack of consensus among operators on the ultimate direction for IP-based mobile services, especially around the use of IMS-based core networks or Internet-type architectures, which will likely take years to resolve, if ever. It will also take considerable time to gain sufficient experience in tuning the network and devices for massmarket mobile VoIP.

It has therefore been seen as essential to provide alternatives in the interim period, which either represent a "road map" to a particular end-point like IMS, or at least buy time while another form of full VoIP is developed. There is also a desire by operators to "sweat existing assets" as much as possible, especially given capital constraints in the current economic climate. During the "interim" period, there are also concerns that any option should not make it too much more difficult to manage aspects like roaming, emergency calling, supplementary services and so forth. There has been a separate hope that any such solution would also work equally well for operators migrating to LTE from either GSM/HSPA or CDMA network backgrounds.

Unfortunately, Disruptive Analysis does not believe that attaining all of these laudable goals are realistic, especially if due consideration is also given to maintaining a first-class user experience. In particular, 3GPP's suggested candidate interim technology, CS Fallback, appears to be a lowest-common denominator approach which is not fit-for-purpose, at least in current guise. Separately, there are also flaws in the notion that the endpoint will eventually be IMS-based VoIP, although that is not the primary point of discussion in this paper.

Introducing CSFB

Circuit-switched Fallback (CSFB) is otherwise known by its 3GPP designation as specification 23.272. It uses various network elements and procedures to move the handset radio down to 2G or normal 3G connection, before initiating a circuit-switched voice call. Although the specification also covers SMS, this does not need the radio to be switched, but instead uses an interface called SGs – essentially sending the messages in one of the LTE signalling channels.

CSFB requires modifications to existing elements within the network (MSCs) as well as specific support on new devices. The MSC modifications are also required for the SMS-over-SGs functionality as well as voice. Exact timing on the availability of these upgrades across the whole pool of current MSC implementations is unclear – but SMS support is vital from day 1 for operational reasons even for data devices.

Alternative interim options for Voice on LTE

As discussed, the ultimate end-point for voice on LTE networks is "pure" VoIP – either an IMS-based solution or some other carrier-optimised IP approach. However, the industry is in general agreement that some sort of interim solution is also required.

In addition to CSFB, a number of other interim technologies have been suggested:

- **VoLGA** (Voice over LTE via GAN), which encapsulates circuit voice within an IPsec tunnel over the LTE bearer. It is an evolution of the voice-over-WiFi standard UMA (standardised by 3GPP as GAN, Generic Access Network), which has existed for a few years, albeit with limited traction. It enables the normal telephony and SMS application on the phone to connect over an IP connection to the existing MSC, via a gateway and handset client. It is advocated by a number of vendors including the sponsor of this paper, with T-Mobile as its principle operator supporter. Disruptive Analysis has discussed

VoLGA in a number of forums, including on its Disruptive Wireless blog[1] - and although it has been a consistent critic of UMA since 2004, it believes that its "repurposing" for LTE is a much more viable development. A good introduction and analysis[2] is provided by consultant Martin Sauter, who has also commented on it extensively on his own blog[3]. An initial attempt to gain 3GPP standardisation of VoLGA did not succeed (mostly on the grounds of the perceived downside of endorsing a third option), despite growing industry support for it amid increasing concerns about CS fallback.

- Nokia-Siemens Networks has developed a solution called **Fast Track Voice**.
- **Acme Packet and Mavenir** have proposed a solution by which an MSC can act as an "application server" for full-VoIP voice, without the need for an IMS deployment.
- Use of non-optimised **VoIP clients on the LTE data channel**, either using SIP-based softphones or proprietary approaches like Skype's. It has been possible to use 3rd-party VoIP on HSPA and EVDO networks for several years, although there have been limitations in terms of quality, integration and battery consumption.

This report does not cover all of these alternatives – VoLGA is seen as the primary alternative to CSFB as an "interim" solution at present, given relatively broad support (not all of it public) and its current status as being closer to being easily "standardisable" compared to the vendor-specific alternatives.

Problems with CSFB

There are numerous drawbacks with the CSFB approach to interim voice and messaging, which Disruptive Analysis believes should prompt operators and standards authorities to look afresh at alternative interim mechanisms. Part of the problem has been that past assessments of the standards have focused mostly on the technical aspects, rather than addressing issues around user experience and behaviour, or impacts on broader application usage and indirect impacts on business models.

The following issues are examined in more details in the next sections of the document:

- Additional call set-up latency
- Requirements on network coverage
- Side-effects of dropping the data connection during voice calls
- Impact on data applications, especially on multi-tasking devices
- Issues relating to SMS support
- Implementation cost and practicalities
- Negative impacts on current or potential new LTE business models, eg MVNOs
- Poor fit with new types of voice application
- Problematic integration with femtocells

[1] http://disruptivewireless.blogspot.com/2009/03/volga-reinventing-uma-for-voice-over.html
[2] http://cm-networks.de/volga-a-whitepaper.pdf
[3] http://mobilesociety.typepad.com/mobile_life/2009/08/volga-voice-over-lte-via-gan-a-technical-introduction.html

1. Call set up times

The worst effect of CSFB is probably the extra time needed to make or receive calls. Call set-up latency is a major factor in determining "quality of experience" with phone calls. Many people remember the seemingly-amazing shift to digital exchanges on fixed-line networks, when calls connected the instant the last digit was dialled. Most cellular calls today are already a retrograde step from this – and making matters noticeably worse with the "latest and greatest" generation of cellular technology is far from ideal.

There have been various attempts made to calculate the impact of CSFB on call establishment times. Although findings vary somewhat based on input assumptions and precise procedures followed, the general consensus seems to be that the best-case scenario is an extra 1-2 seconds, an average perhaps 2-3 seconds, and worst-case may be as bad as 6-8 seconds. Much of the extra time comes from the need for the phone to start up the 2G/3G radio, which involves measuring different channels to find the appropriate cell and frequency to connect.

(As a reference, document SP-090633 submitted to 3GPP by Huawei and China Unicom states *"Rel-8 CSFB to GERAN/UTRAN adds several seconds compared to 2G and 3G native CS calls – between 2 to 4 additional seconds")*

The absolute worst-case scenario probably occurs when two LTE handsets communicate with each other, and both need to fall back to 2G/3G. Although some of the procedures may occur in parallel, the overall call set-up time is likely to be unreasonably poor. Even in early deployment of LTE handsets, this scenario may be quite common, for example where business customers purchase significant volumes of identical LTE-capable devices.

It is also mostly likely to impact high-end smartphone users first – a double blow if user experience worsens, since these are typically an operator's best customers, and also those that tend to influence behaviour of the rest of their social network through recommendations. A further consideration here is that there is likely to be a strong overlap between the worst-affected users, and those most able to experiment with 3rd-party "over the top" VoIP. Deliberately creating a situation where a side-by-side comparison between operator voice services and, say, Skype shows a clear performance gap would be highly counter-productive and may lead to viral adoption of competing services.

Lastly, irrespective of the wishes of operators, worsening user experience may prompt certain device vendors to take matters into their own hands, either embedding VoIP unilaterally, or developing proprietary workarounds. CSFB advocates may wish to imagine themselves in a meeting with Steve Jobs of Apple, explaining why an extra 5 seconds delay is an acceptable user experience penalty, amply justified by LTE's improved peak speeds and theoretical efficiency.

Going beyond normal telephony, perhaps the easiest argument against CSFB is that of additional latency for emergency calls. It would be a brave operator that knowingly adds extra seconds to the time taken for a health or crime victim to reach a safety answering point. Certainly, any network engineer contemplating this might wish to check on potential liability issues with the company's legal experts before reaching a decision.

2. Impact on coverage and handoff for 2G and 3G

The notion of falling back to 2G or 3G from LTE has an obvious pre-requisite: there needs to be a suitable network with coverage available. In many cases, it is likely that this will not be an issue – many deployments of LTE are envisaged as a way of boosting network capacity in hotspots for mobile broadband usage, which implies that low tiers of connectivity should be readily available.

However, there are some very particular concerns in other scenarios:

- Deployment of LTE in 700MHz or 800MHz "digital dividend" bands is expected to be used for extending mobile coverage beyond the bounds of current services, especially for operators without existing sub-1GHz spectrum holdings. Lower frequencies tend to travel further at a given power level, and penetrate better indoors. "Falling back" to 1.8GHz or 2.1GHz 2G or 3G networks may well not be a viable option.
- There is an expectation that some LTE operators will be "greenfield" providers without 2G or 3G assets. If they wished to support CSFB voice, they would need to arrange suitable MVNO relationships, with operators that had suitably-modified MSCs.
- For those operators that currently have 2G networks operating in 900MHz bands, the need for CSFB may impact plans to refarm those bands either for 3G or for LTE.
- There may be added complexities when roaming, especially where a GSM/LTE device roams onto a CDMA/LTE network, or vice-verse.

In addition, forced vertical handovers are probably the least reliable aspect of many current 3G networks – switching back to 2G is probably the cause of more call drops than virtually anything else beyond coverage blackspots, The chances of this situation improving, on Day 1, for a mechanism forcing new LTE-to-2G/3G shifts, seem slim. Performance will almost certainly be impacted negatively.

3. Dropped data connections

One of the most critical problems with CSFB is that it will likely drop any concurrently-running LTE data connection in the process. As mentioned above, users still commonly experience problems with vertical handover for 2G/3G data, which does not suggest that an LTE-to-3G or LTE-to-2G transition will be painless, either for the user or most applications. Given the growing range of "always-on" applications, from push-email to streaming-media services like Spotify, deliberately breaking the IP connection in order to make or receive a phone call is pretty poorly-conceived.

As well as phone-based problems, this also impacts a variety of PC-based applications that may incorporate voice. Conferencing applications in particular rely on concurrent voice and data streams, while it seems probable that emerging social networking tools will also enable phone calls to be initiated between "friends".

This problem of dropped IP connections during CSFB has wider ramifications as well – there may well be extra issues and costs elsewhere, if the interruption impacts a paid-for service (eg download) or one on which the user is otherwise heavily dependent. The prospective use of LTE for mission-critical services like healthcare monitoring data is a case in point.

4. Poor fit with Multi-tasking devices

An important consideration with the advent of smartphones is the growing prevalence of devices with true "multi-tasking" capability. There may be various concurrent applications running "in the background" when a call comes in or initiated – perhaps streaming music, backup applications, presence, push email, ongoing downloads, VPNs, antivirus or other security mechanisms and so on.

At present, there is also a huge push towards "cloud services" by the operators and others. It is a fairly strong bet that these will be intolerant of sudden shifts from one radio connection to another, with a significant latency period involved. Will voice calls always have priority in these situations? How will the user be able to reconfigure priorities dynamically? The phone will have dropped the LTE connection even if the caller rejects the call, interrupting any other apps they may have been using.

It is of course possible that Apple or Google will find a convenient way around this – perhaps re-routing and terminating the CSFB call on a VoIP gateway that can signal "over the top" on LTE, but that is hardly likely to be seen as an ideal solution by 3GPP or the operators.

5. Limitations in supporting SMS

Support of SMS over LTE has emerged in 2009 as a major priority, missed in the original expectations around voice and messaging through IMS or CSFB. Few people on the radio network engineering side seem to have appreciated that mobile broadband services are often heavily-dependent on SMS for internal operational reasons, such as device configuration, updates to roaming partner lists and so on.

One operator has suggested that for its HSPA services, as many as 20 separate IT systems are dependent on SMS as a bearer – clearly something that would take considerable time and cost to modify. In addition, European regulations mandate the use of SMS as a mechanism for "advice of charge" for mobile data roaming fees, while many operators have started providing end-user SMS software to enable sending of messages directly from a laptop via a 3G modem. In short, SMS is essential, even on data-centric devices.

In a submission to 3GPP in June 2009 (SP-090429), a range of companies including Vodafone, China Mobile, Huawei and Alcatel Lucent stated that "As the availability of an SMS solution appears to be necessary for the commercial launch of LTE, these issues would seem to need resolution as part of Release 8."

In other words, the lack of broad and well-performing SMS support is a show-stopper for LTE.

As discussed above, it should be possible for an operator to use "SMS over SGs" without full-scale CSFB deployment. This procedure also does not require dropping the LTE connection and falling back to 2G/3G. However, there may still be some substantial costs involved with upgrading all MSCs to support this specification – as well as a timing issue.

More importantly, the SMS-over-SGs approach has some significant limitations even when used without fallback, resolutions to which are still only now being discussed in standards bodies. Problems relate to provision of information for charging purposes, "message waiting" signals and delayed delivery when a mobile is out of coverage, sending multiple ("concatenated") SMS messages, multiple-addressing of sent messages, location data (important for lawful interception) and so on. A particular scenario – what happens to SMS received during the fallback procedure itself – is a particular issue which might affect voicemail notifications which are often received while a user dials in response to a missed call.

Put simply, although the SMS-over-SGs part of the CSFB specification does not require the device to be forced from LTE back down to 2G or 3G, it still operates as a "workaround" with some severe deficiencies that are likely to cause operational problems or worsened user experience. Vodafone and RIM have proposed some alternative approaches to "SMS only" support which they hope will be adopted in R9.

6. Costs and practicalities of CSFB

The costs associated with temporary CSFB migration for LTE remain unclear, especially given the likely need for ongoing updates of specifications to work around problems identified here. There are impacts on both network (MSC) and handset – although obviously there are also costs associated with other approaches for telephony as well. Furthermore, there are implications in the LTE infrastructure, with a need for CSFB support in eNodeB and MME as well.

There is also an additional IPR, software and silicon cost incurred, since the adoption of CSFB forces all LTE devices to also support 2G and/or 3G radios if voice is needed. In addition, the issues mentioned above, such as multi-tasking and data connection support may require additional software development and integration for work-arounds. It is important that any expected deployment accounts for device-side cost elements (and delays, subsidies, support etc) as well as network capex. Lastly, there are different methods for implementing CSFB – and those which have the best performance on metrics like call setup time may require upgrades to the old 2G/3G networks.

7. Negative impacts on LTE-specific business models

One of the main selling points of LTE is that it is supposed to encourage and foster new business models for mobile operators, especially as certain aspects of the competing WiMAX technology are specifically intended to enhance flexibility. There is instead a possibility that CSFB may mean that LTE may entrench old business models.

Consider the scenario of a sophisticated new wholesale model developed by an LTE operator, charging for differentiated, QoS-based data connectivity through an "MVNO 2.0" relationship with a partner. Numerous possibilities could be considered, with the addition of extra features like application-based policy management, addition of extra features around advertising and location APIs, and so forth. A gaming-focused MVNO could pay extra for optimised latency, for example. Now imagine that the MVNO has to drop back its data connectivity during phone calls to the 2G or 3G network, which is supported by legacy IT systems, less-granular billing and so forth.

It seems more likely that a 3rd-party VoIP approach would be used instead, reducing the attractiveness and revenue potential for the host LTE provider.

8. Poor fit with advanced voice services

A major area of innovation and opportunity for telecom opportunities is around what is being termed "Voice 2.0", also known as "voice mashups". This involves linking voice with other applications, for example embedding voice capabilities within a corporate application or game. A call might be invoked inside a browser or web application, either resident on the handset or from the network side. There is huge interest by operators in monetising their voice capabilities beyond mere "person to person telephony".

As a simple example, conferencing and collaboration applications like WebEx are being extended to mobile devices. Degrading the data connection in order allow voice is a retrograde step. This is likely to drive such software developers to use 3rd-party VoIP rather than operator voice as part of the proposition.

Another angle to this is the move towards voice communications with much richer contextual information – which may be derived from the handset telephony software "knowing" extra data to enhance the phone call, for example if it its light sensor detects that it's in a darkened room, and that it's on charge. Decoupling the telephony application from the data environment, at just the point at which the 100-year old "telephony product" is evolving to something more intelligent and value-added is highly counter-productive. While such information could be transferred quite easily to 2G or 3G, the chances that something unpleasant happens to the application during the transition seems quite high.

Along with "voice 2.0" services, another slow-burning trend which could be extinguished by CSFB is that of the shift towards "high definition" voice. Although this has been widely used in the VoIP community for years, it has taken a long time to penetrate the mobile marketplace, despite being technically feasible. One of the first deployments has been in Orange's network in Moldova.

9. Problematic integration with femtocells

Many operators are looking into deploying femtocells as a core part of their LTE strategies. Unlike previous generations of cellular technology, low-power indoor cell access points have been defined upfront as a core part of the radio infrastructure. There are numerous use cases – improved indoor coverage (especially for LTE at 2.6GHz), offload onto fixed broadband for cost reasons, additional new "femtozone" applications and so forth. There is even speculation that some LTE networks will be built "inside out", starting with femtos before the macro network, perhaps even hoping to displace or complement WiFi for in-building network access, via licensed spectrum

The idea of CSFB fits very poorly with LTE femtocells. An LTE device camped onto a femto would either need to fallback to 2G / 3G in the femto itself, or look for a macro cell-site instead. Adding 2G into femtos is extremely complex, while adding 3G increases cost, complexity and time-to-market. Conversely, accessing the macro network is obviously dependent on coverage, and may have a huge performance gap with the femto for data services running in parallel. There is no reason that LTE

femtocells should not run at maximum throughput rates, assuming that the ADSL/cable/fibre connection can support this – a huge gap if the device falls back to GPRS or even HSPA.

10. Other issues

- **Testing** From the previous discussion, it seems likely that CSFB might give particularly poor results in certain specific scenarios. It is not clear that all of these have been identified and prioritised as test cases. In particular, it seems likely testing at the end-user experience level is needed as well as underlying protocol performance checks. At the time of writing it was also believed that SMS-over-SGs test cases were not yet comprehensive.

- **Handsets sold through non-operator channels** An open question for all mechanisms for voice-on-LTE is which variants appear on "vanilla" phones sold through non operator-channels. Although some early LTE networks will have strongly carrier-controlled devices (eg Verizon, DoCoMo), this is far from being universally true. Depending on how the devices are set up when they leave the factory, users may have to configure their telephony service in complex ways.

- **2G / 3G switched off in device** Many devices have manual over-rides which enable the user to select which networks can be accessed. For example, it is quite common for users to switch off 3G radios to conserve batteries, reduce potential roaming bills or force the phone to 2G networks with better coverage. Clearly, any such interference on a CSFB-enabled device would have negative consequences.

- **CDMA** One of the principle perceived benefits of LTE is that it provides a migration path for both GSM-based operators and those with a CDMA heritage. Most of the major CDMA carries, notably Verizon, have made a decision to migrate, through a period of coexistence. The Release 8 CSFB process introduced significant extra delay (up to 4 seconds in worst-case scenarios). This would result in longer call set-up times and thus notably worsened user experience compared to previous systems: not ideal on what is likely to be marketed as a state-of-the-art "4G" technology. That said, some of the other proposed solutions to voice-on-LTE such as VoLGA would not be easily made applicable to CDMA operators either.

  A submission to 3GPP (SP-090447) in June 2009 from a large number of network vendors stated: "Since this performance issue would create a significant degradation in the user experience, it may negatively affect the LTE rollout date. Consequently, we propose to address this issue as soon as possible." This refers specifically to the fallback operation for CDMA operators moving calls from LTE to CDMA2000 1x networks.

- **Unexpected dependencies:** As well as delay for emergency calls, there is a further problem with certain scenarios for inbound calls from the public safety services to an LTE handset. According to a 3GPP submission in September 2009 (TD SP-090577) from a number of leading Japanese vendors and operators, if the MME (part of the LTE/EPS core network) is overloaded, then some emergency calls that involve CSFB might be rejected. Although perhaps an unlikely occurrence, this is a "show stopper" as local regulations

stipulate that such calls are never blocked. Although this particular issue should be fix-able fairly easily, it is a good example of unexpected consequences involved with the need to shift between radio bearers during call setup.

IMS and OneVoice

The "official" standardised long term solution for voice and messaging on LTE uses the 3GPP IMS architecture as a control plane and service layer. Intended as a carrier-grade IP networking and services platform, spanning fixed and mobile networks, it is often endorsed as the "end point" for LTE operators – but with the caveat that the timelines and efficient migration demand an interim solution. In theory, IMS should enable operators to develop and deploy an array of services, as well as maintain control and bill for them easily.

Reality is rather more complex, especially as any notional IMS service is typically available via the open Internet and open devices already. It seems that operators' gold-plated QoS philosophy exemplified by IMS sits uneasily with the Web-style "perpetual beta" approach where services are developed rapidly and improved over time. Add in concerns about cost/complexity, issues about interoperability and "optionality" in specific implementations, poor fit of IMS with certain business models and perennial delays in producing IMS-capable handsets and it is unsurprising that many operators (or specific groups within them) remain unconvinced.

In general, Disruptive Analysis believes that IMS is suitable for VoIP in some fixed-operator broadband scenarios, but is less well-suited to mobile deployment. Some fixed VoBB implementations use IMS, while others use alternative "NGN" architectures such as more lightweight SIP networks. This is less problematic than in mobile, as the handsets are generally much simpler and less dependent on complex client software.

It is worth noting that although VoIP (IMS-based or otherwise) has been broadly adopted in some fixed telephony markets such as France and Japan, it is still comparatively rare. It is notable that certain operators such as the UK's BT have reversed earlier plans to switch off their CS-based PSTN networks in the short term, instead continuing with their legacy infrastructure while focusing investments elsewhere, such as the access network or IT/Internet service platforms. Conversely, those operators with both fixed and mobile arms are tempted by the potential cost savings of a single core network and application platform.

In November 2009, a number of operators and vendors announced a recommended method for implementing IMS-based telephony for LTE. Called OneVoice, this was essentially a definition of "bare bones", basic VoIP service that could be implemented on IMS platforms, enabling interoperability between different operators. It essentially de-optioned various parameters within existing 3GPP standards, reducing emphasis on some of the less-necessary elements like video calling or combinational services. Compared with the earlier but much-ignored IMS specification called MMtel, it seems to be a rather more realistic view of LTE-based voice services, eschewing questionable aspects such as presence in order to "get something working" sooner.

While all this is good in principle, it is only relevant for those operators (or parts of operators) that are believers in the broader IMS vision. For the sceptics, it is unlikely

to change their opinion of the overall business case for IMS deployment (or lack thereof). At present, there are no obvious new sources of revenue associated with investment for mobile IMS, nor any clearly comparable cost-savings as seen in some fixed-line implementations. There remains limited appetite for replacing well-honed circuit switched voice infrastructure (and its associated asset value) with unproven new technology which has no clear upsides. All of the suggested services enabled by IMS are already available using Internet-type platforms, often in more flexible form with greater user appeal.

It is conspicuous that one of the OneVoice signatories (Vodafone) is also very publicly pursuing a distinctly non-IMS strategy for social networking and address-book management (its 360 service).

While OneVoice may help smooth the path to LTE voice for IMS advocates, it does not remove the need for an interim solution for the next 3-5 years, nor one that perpetuates circuit-switched telephony for those operators that prefer to focus new services investments outside of their core network.

The bottom line is that a workable interim solution is needed even for IMS-centric operators. For others, the "interim" option may last a long time, and perhaps head in the direction of a different end-point. It is extremely unlikely that broad consensus will be reached on medium-term and ubiquitous IMS deployment, which means that any interim solution needs to be robust and practical.

Does it matter if LTE is used for data-only services?

There is a possible valid argument that early use cases of LTE are likely to be first driven by data-style devices like dongle-style USB modems, or embedded modules. If that is the case, then the need to support voice at all could be thought to be small. HSPA first appeared in datacards, although most of the first WCDMA products were actually phones. In that case, the presence of CSFB could perhaps be deemed to be "good enough" in the short term, for the few devices that needed to support occasional telephony connections.

However, this pre-judges both the business models that some operators may wish to pursue, as well as the typical usage modes of data-type devices. While it appears that some early LTE deployments are being driven by a need for data, it may be that other business cases are predicated on an early switch-over to voice. It will vary significantly based on a given operator's spectrum holdings, device and services strategy, existing voice and data coverage, expected user behaviour and requirements and so forth. An Asian operator wishing to focus early LTE rollout on commuters might be different from a European provider wanting to provide extra capacity for suburban students with mobile broadband.

It is also worth pointing out that many of today's data-centric devices support CS voice and (especially) SMS. There is also a good argument that operators will wish to put their own telephony applications onto such terminals, in order to provide in-house competition for Internet VoIP service software which might be downloaded.

Is CSFB all about politics?

It is always difficult to dive into the politics and back-stairs machinations around standards and industry initiatives. There are always a broad set of commercial and personal agendas at play, as well as limits on areas that actually cannot be discussed for fear of anti-trust rules. Decisions are often made by groups with very rigidly-defined areas of responsibility, with clear delineation between separate parts of the overall mobile ecosystem.

Nevertheless, it seems rather strange that CSFB is so far from being fit-for-purpose, at least in its first iterations. It has led some observers, including Disruptive Analysis, to speculate whether its true value to 3GPP is in forcing more operators towards IMS-based voice, earlier than they may have otherwise chosen – if they choose it at all. If this rather-cynical scenario does contain a grain of truth, then it may backfire spectacularly – rather than using LTE as a lever to advance the adoption of IMS, it may in fact act as a brake on LTE overall.

While this is not an appropriate venue for a full "game theory" analysis, the future success of IMS in the mobile sector is dependent on most or all operators deploying it, in order to achieve network effects and interoperability. But given the relative competitiveness of technologies like HSPA+ against LTE, it may mean that IMS-sceptics prefer instead to eschew the whole of the LTE upgrade, instead pushing for either full 4G or continued evolution of HSPA. Alternatively, they may simply pursue a data-only strategy around LTE, or one which maps more neatly to the WiMAX-style view of the world, where voice is delivered as a non-integrated and non-standardised service over a mobile IP bearer.

The biggest risk comes from the potential combination of two unhappy circumstances:

- Widespread use of IMS Voice is likely to be delayed and not supported ubiquitously by all operators. Some operators remain staunchly opposed to IMS having an important role. Almost all operators have failed to gain early practical experience of any form of mobile VoIP on HSPA or EVDO, which is likely to require substantial tuning and optimisation before it reaches the quality experienced for CS voice.
- CSFB is deemed to be so sub-standard that it cannot be justified as a solution for voice on LTE.

This would have a number of effects:

- Operators may focus LTE deployment solely on data-only devices and use cases.
- Operators may delay LTE deployment entirely.
- Operators will need to continue investing in 2G/3G solutions to add voice capacity.
- 2G/3G standards will continue to evolve until the technologies become much closer to LTE in functionality, cost and performance, reducing the business case for LTE still further.
- Third-party VoIP services would be handed a golden opportunity to gain traction.

Salvaging CSFB

Ironically, there may be theoretical ways to make CSFB work better, but which involve solutions so anathema to the standards bodies that they get ignored. Take for example the call set-up latency issue. In this scenario, the act of initiating an outbound call starts the process by which fallback occurs, prior to establishing the connection. The time taken to associate with the 2G/3G network is a significant impediment here.

Yet there is a way for the phone to "know" in advance that an outbound call is likely, and start the process pre-emptively. At the UI level in the phone, when the user either starts scanning the phone-book application, or entering a multi-digit number into the home screen, or looking at the missed-call register, it is a pretty good bet that they are about to make a call. Yet the notion of using the UI and "top layer" applications to drive radio connections automatically runs completely counter to the preferred mechanisms espoused by many in standards bodies.

It is interesting to see that some industry groups are now going beyond the strict notion of "layers", and are using application-level software on top of handset OSs, to drive connection and routing decisions. Thus far however, 3GPP has eschewed such an approach, preferring to keep its scope of activities to much lower-tier levels of firmware in most devices.

Another approach may be in designing handsets that can simultaneously run dual radios (eg GSM and LTE), using one for voice and the other for data. This sounds good from a theoretical point of view but may have negative impacts on battery, software integration and RF development and testing.

Conclusion & comparison vs. VoLGA

Disruptive Analysis believes that in current form, CS Fallback is unsuitable as a broadly-deployed interim solution – especially for LTE operators that do not expect a swift transition to IMS. While it may be made workable for certain operators that retain an iron grip on handset software, an entrenched business model and abilities to provide a highly-customised user experience, it has severe deficiencies for many others. While there are likely to be some work-arounds and enhancements to CSFB to address some of the problems, it seems unlikely that these will solve all the concerns raised here.

There are a number of other alternatives for the "interim" solution. A full discussion of all of these is outside the scope of this document – although Disruptive Analysis believes that Internet-style VoIP (perhaps partnering with Skype or Google) could work for the more "heretical" operators who refuse to be blinded by the unhelpful rhetoric deriding "dumb pipes".

But for other operators that want to retain control over inhouse voice applications and which have robust CS platforms with several years' working life and spare capacity left in them, VoLGA is looking like a realistic option – or at least one worthy of formal investigation and testing, as well as greater attention by the standards bodies. It is certainly not without its own challenges – it also requires changes to handsets, as well as a mechanism for allowing the network to trigger LTE-to-3G/2G handovers for

VoLGA calls, originally defined as part of SR-VCC (single radio voice call continuity). It is also purely a mechanism for delivering "old school" CS-type voice services rather than the more advanced types of Web/voice integration described above – although potentially the voice traffic could be treated as a packet application/object available over IP as "mashed up". But, critically, it should work with shorter call setup times and not "break" concurrent data applications using the LTE radio. SMS support should also be simpler.

(Note that Disruptive Analysis has been a consistent critic of VoLGA's ancestral technology UMA when applied to dual-mode WiFi/cellular. However VoLGA appears significantly more practical and attractive, as it avoids many of the extra complexities and limitations engendered by the WiFi aspects of UMA. In fact, in 2006 we even suggested "2G over 3G" as a possible more-useful application of the technology).

Given that a substantial amount of investment is likely to occur in "interim" (or "early") voice-on-LTE solutions, Disruptive Analysis believes VoLGA is a stronger contender than CSFB. Neither is in its final version, but VoLGA seems to be a much better starting point.

Background to this study

This study is an independent research paper based entirely on the research and opinions of Disruptive Analysis Ltd. It is intended as a critical analysis of CS Fallback as a solution to providing voice services on LTE networks. Although it has been commissioned by the Kineto Wireless, it does not represent the official views of that organisation.

About Disruptive Analysis

Disruptive Analysis is a technology-focused advisory firm focused on the mobile and wireless industry. Founded by experienced analyst Dean Bubley, it provides critical commentary and consulting support to telecoms/IT vendors, operators, regulators, users, investors and intermediaries. Disruptive Analysis focuses on communications and information technology industry trends, particularly in areas with complex value chains, rapid technical/market evolution, or labyrinthine business relationships. Currently, the company is focusing on mobile broadband, operator business models, smartphones, Internet/operator/vendor ecosystems and the role of governments in next-generation networks.

Disruptive Analysis attempts to predict - and validate - the future direction and profit potential of technology markets - based on consideration of many more "angles" than is typical among industry analysts. It takes into account new products and technologies, changing distribution channels, customer trends, investor sentiment and macroeconomic status. Where appropriate, it takes a contrarian stance rather than support consensus or industry momentum.

Disruptive Analysis' motto is *"Don't Assume".*

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