Technical Specification Group Services and System Aspects Meeting #19, Birmingham, UK, 17-20 March 2003

TSGS#19(03)0066

3GPP TSG-SA2 Meeting #30
Milan, Italy, 24 – 28 February 2003

Tdoc S2-030998

Title: **Liaison on eTFO**

Source: **SA2**

To: **TSG SA**

Cc : **TSG CN**

Contact: Alexander Milinski
Alexander.Milinski@siemens.com
+ 49 175 180 45 12

Contact: Claire Mousset
Cmousset@nortelnetworks.com
+ 33 1 39 443720

0. Introduction

At the last TSG SA plenary meeting #18, SA2 was tasked to study the system aspects and impacts of enhanced TFO (eTFO).

The present document provides the results of this study. It is organised as follows: section 2 provides short descriptions of TFO, TrFO, and eTFO. In section 3 the issues studied by SA2 and the initial answers are described. Given the time limitations, these initial answers are provided based on the available input.

1. Summary

3GPP SA WG2 has studied the proposals for eTFO and possible impacts on the overall system. Thanks to the big effort of all involved parties, a much clearer picture of eTFO and possible impacts is available than at SA#18.

The protocol messages for eTFO would be built upon the existing TFO messages. eTFO does not work only end-to-end like TFO does, and additional MGWs need to understand the Nb eTFO PDU.

If eTFO establishment fails, the eTFO capable MGWs can use G.711 and try to establish TFO.

Framing protocol and user plane impacts are considered to be the biggest impact of eTFO on the overall system. There are currently different interpretations on how G.711 may be carried over Nb according to existing standards. Depending on the correct interpretation, there may be major or minor impact on the user plane support required for eTFO. SA2 notes

that the expertise for these topics is in CN3 and CN4 who would need to be involved from the beginning of any eTFO standardisation.

TFO works over packet networks. eTFO provides further optimizations.

eTFO would provide bandwidth savings, but they are less than with TrFO.
eTFO would provide transcoder resources saving, but they are less than with TrFO.
TrFO requires OoBTC (including BICC signaling) at the MSC server, and TrFO uses MGW resources for RFCI handling, TrFO break and TrFO/TFO interworking. eTFO does not require these capabilities from the network.

When comparing eTFO and TrFO within packet networks, SA2 concludes:

- Rel4 TrFO can already deliver bandwidth and resource savings (transcoder's resources) within a fully compliant bearer independent core network connected network
- eTFO can deliver bandwidth and resource savings (transcoder's resources). It is intended that this would require no enhancements outside the MGWs
- eTFO can also be used between TCMEs

2. Technical description of eTFO

This section provides a technical description of eTFO from an architectural perspective showing the relationship with the already standardised TFO and TrFO functions. The technical description of eTFO is introduced by first providing a short description of the already standardised TFO and TrFO functions.

2.1. Tandem Free Operation (TFO)

Tandem Free Operation (TFO), originally designed for TDM networks, was introduced in GSM R'98 and is specified in TS 28.062 for UMTS and GSM in Release 4 and Release 5.

TFO allows mobile-to-mobile calls, operating with the same codec, to bypass unnecessary transcoding in the network and therefore utilise a single stage of speech compression end to end. The removal of transcoding improves speech quality and reduces delay. Furthermore TFO enables wideband speech telephony in TDM networks.

TFO operates in-band following call set-up. The call is set up as normal with G.711 PCM on the TDM network between the transcoding functions. TFO-enabled transcoding functions steal bits from the speech samples in the PCM frame to negotiate codecs and initialise TFO. Once in tandem-free operation the compressed speech together with the TFO control information is placed in the least significant bits of the TDM connection for transmission. TFO is illustrated in Figure 1.

While TFO was originally designed for TDM network, it should be noted that TFO can also be used in packet networks.

TFO requires TFO compliant In Path Equipment (IPEs)

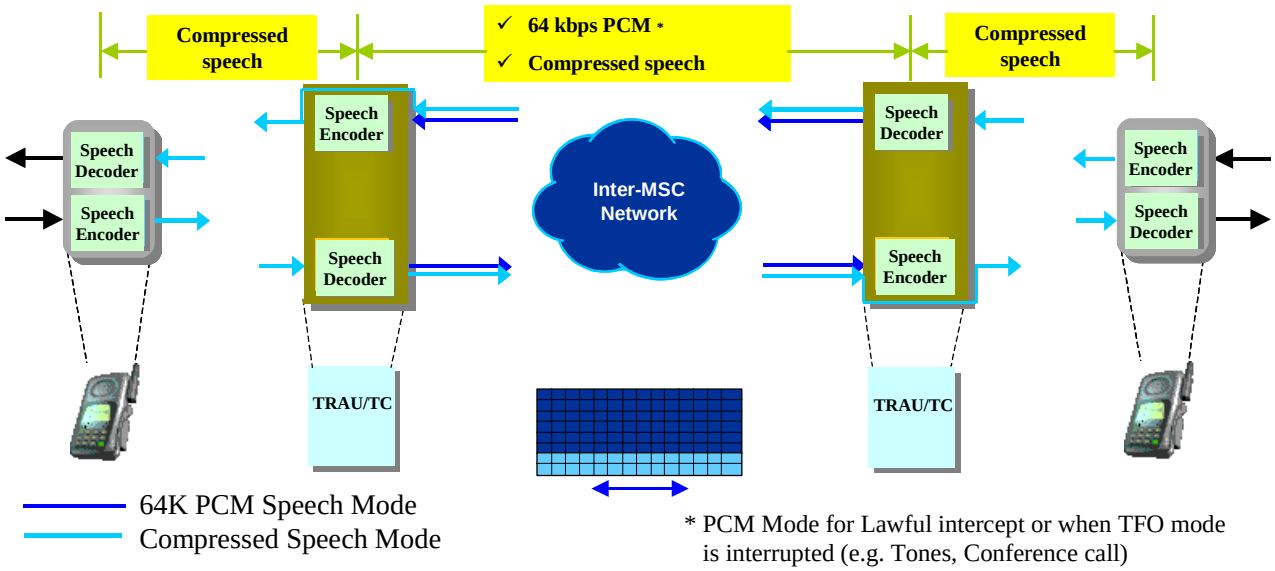


Figure 1. Tandem Free Operation

2.2. Transcoder Free Operation (TrFO)

Transcoder Free Operation (TrFO) employs Out of Band Transcoder Control (OoBTC) as part of a BICC-based bearer independent core network to negotiate the removal of transcoders from the call path as part of call set-up.

OoBTC is defined in TS 23.153 (REL-4 & REL-5) for UMTS and GSM.

The removal of transcoders from the call path improves speech quality, reduces delay and frees up processing resources (transcoders).

TrFO makes use of the existing IuFP to convey compressed speech in packet networks (Nb interface). The use of compressed speech in the packet core provides bandwidth savings over G.711.

TrFO needs to interwork with TFO (as defined in TS 23.153) to provide an end-to-end solution for calls that have a TDM component (i.e. GSM, calls transiting a fixed network).

The basic architecture for a UMTS to UMTS TrFO connection is illustrated in figure 2.

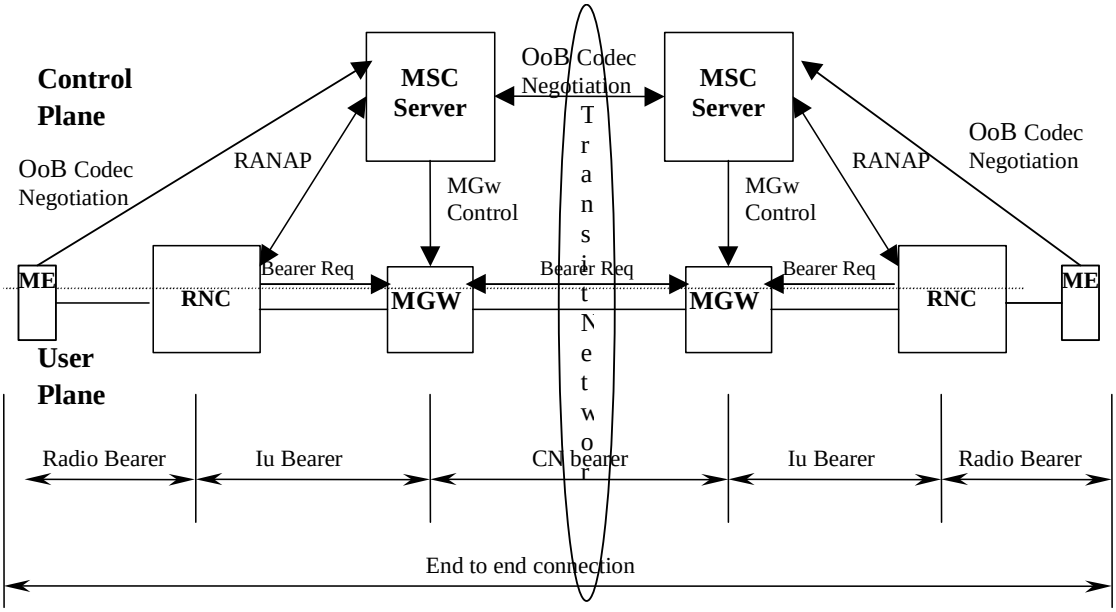


Figure 2. Transcoder Free Operation

2.3. enhanced Tandem Free Operation (eTFO)

This section describes eTFO based on the information provided to SA2 by the companies proposing to study eTFO.

eTFO enhances TFO by making the protocol bearer independent in order that tandem-free operation may be applied to packet networks in a manner that provides bandwidth savings and reduce the delay further.

eTFO is fully backward compatible to TFO, using the existing protocol set but extending the transport mechanisms to include packet networks in addition to TDM. As with TFO, eTFO would be initiated in-band following call set-up.

In ATM networks, the packet AAL2 bearers use 64 kbps maximum bit rate and an average bit rate which is traffic engineered. The AAL2 bearers are placed in an ATM VC utilising real time VBR traffic class. The call will set up as G.711 using this maximum of 64 kbps and if a common codec can be negotiated, the codec will change in-band, which will lead to using less bandwidth from the rt-VBR bearer.

With eTFO, the bearer is not modified to the actual bandwidth used, but the multiplexing gain is achieved by engineering, which takes into account the eTFO calls and therefore admits more calls.

The evolution of TFO to eTFO reflects the general evolution of networks from TDM-based to packet-based; eTFO takes advantage of the packet network capabilities in order to achieve bandwidth and delay reduction. In TDM networks eTFO simply becomes TFO. eTFO control information is sent together with the compressed speech over TDM connections according to the existing TFO frame formats. Over packet connections, eTFO control information can be sent more efficiently in a separate control channel in the user plane after establishment of eTFO operation.

This means for eTFO to work, the transcoders must be updated to support the enhanced in-band signalling for eTFO. It is FFS whether the separate control channel in the user plane needs any update of the IuFP or a new framing protocol,or neither. Note that there is no need for a specific control channel at the beginning of the call. At the beginning of the call it

is exactly as the existing TFO, the TFO messages are exchanged through bit-stealing on G.711 PCM samples.

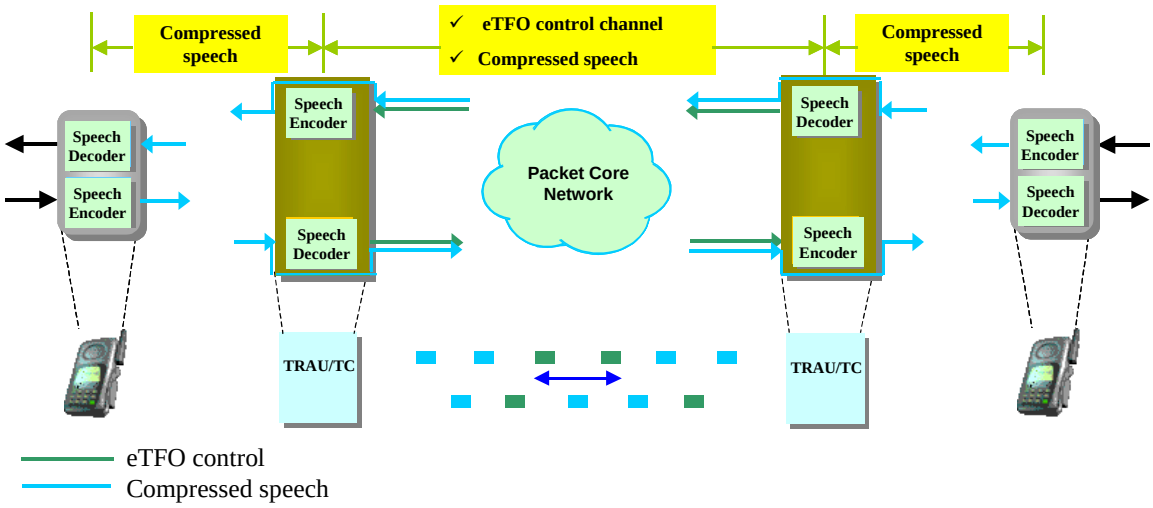


Figure 3. enhanced Tandem Free Operation

3. Questions and Initial Answers on eTFO

This section summarises a number of questions related to eTFO. The questions are presented together with the initial answers provided at SA2#29.

3.1 To which networks shall eTFO be applicable?

According to 2.3, eTFO is bearer independent. The only bearer independent call control protocol currently standardized in 3GPP is BICC (see TS 29.205), but outside 3GPP in fixed networks / transit networks other combinations of packet networks/call control protocols might be used. Interworking to which networks/call control protocols should be considered in this study?

Which of these call control protocols support an out-of-band codec negotiation (like BICC) on their own, which do not?

Answer:
eTFO is bearer independent . eTFO will not interwork with packet network call control as it is not related to call control but is entirely inband codec negotiation.

In 3GPP, the scope of eTFO is Bearer Independent Core Network but all codec negotiation happens in band independently of the BICC protocol.

It is intended to specify eTFO in such a way that it can be run with other call control protocols than BICC.

eTFO, like TFO, can be used with TDM and packet transport. Actually eTFO is a superset of TFO.

3.2 More detailed message flows

More detailed message flows for eTFO should be provided for the most common call setup scenarios (see e.g. TS 23.153 and TS 23.205). These message flows should especially

show the interworking between the eTFO-Signalling and the bearer control protocol during the establishment of the eTFO control channel.

These message flows are a prerequisite in order to study the following issues:

- interworking to TrFO
- interworking to TFO
- Insertion of tones and announcements (this may happen also while the call is active)
- Transfer of DTMF tones (in-band or out-of-band?)
- Legal interception
- Interworking with supplementary services, e.g. Multiparty.

Answer:

Taking into consideration the March deadline we cover only the high level system issues raised at SA. More detailed questions can be addressed once the work item is approved. This should include CN working groups CN3 and CN4.

A high level procedure for basic eTFO establishment over ATM is provided in figure 4.

Figure 4 describes the high-level procedure for TFO/eTFO establishment. The scenario describes a GSM to UMTS call with TFO running between the TRAU and tMGW1 and eTFO in the centre section between the 2 terminating MGWs (tMGWs). The yellow boxes contain the TFO state and the hatched aqua boxes illustrate at which points in the establishment procedure P-F conv or F-P conv is active in the tMGWs.

P-F conv is the conversion from TFO over PCM to TFO over Nb Framing protocol, and vice versa for F-P.

Note that eTFO negotiation between tMGW1 and TC reuses the existing TFO messages and protocol design.

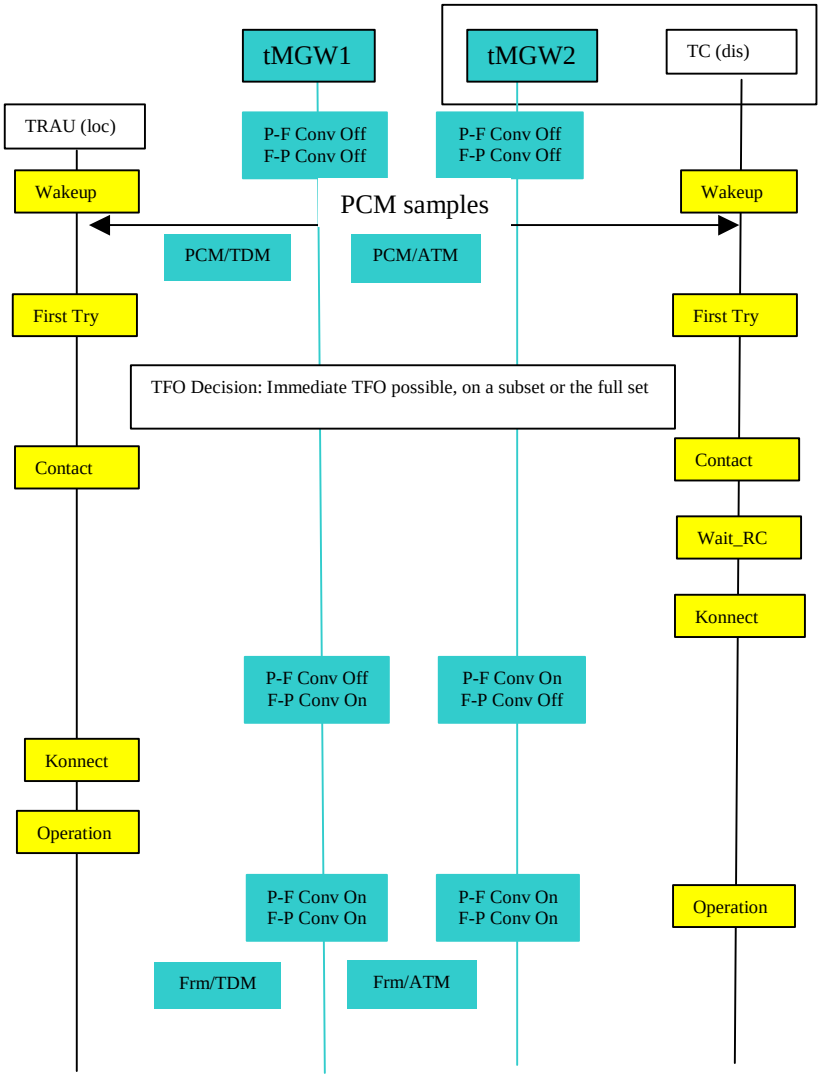


Figure 4: eTFO establishment procedure

From a system perspective, the issues listed above will be solved either by:

- general procedures that are also used by TrFO (i.e. BICC procedures for the transfer of DTMF, Legal interception), if supported, or
- fallback to TFO procedures (for supplementary services, tones and announcements) which can further do a fallback to G.711, followed by re-initialisation of eTFO. This second option is used if the TrFO procedures can not be used. If TFO compliant IPEs that do not support eTFO are introduced to the call path, eTFO will fallback to TFO.

3.3 User Plane Framing

What framing protocol is used for the separate eTFO signalling channel over the packet network?

eTFO in comparison to TFO makes use of the compressed speech bit rate after eTFO establishment. How will the change from G.711 to AMR compressed speech be handled in the user plane?

Answer:

There is no specific control channel at the beginning of the call. At the beginning of the call it is exactly as the existing TFO, the eTFO messages are exchanged through bit-stealing on G.711 PCM samples.

eTFO user plane does not need to use the Iu initialisation procedure to configure RFCIs. eTFO could carry codec mode information in TFO codec mode bits. The change from G.711 to AMR compressed speech would be entirely handled by the in-band eTFO protocol.

There are several options for the choice of framing protocol for eTFO on the Nb interface. These options will be assessed as part of the development of eTFO stage 3. The Framing protocol options can be split into 3 steps.

1. Connection establishment framing protocol (G.711 mode). eTFO is not active.
2. eTFO establishment. G.711 mode with bit-stealing for eTFO signalling.
3. eTFO framing protocol (compressed speech mode)

There are currently different interpretations on how G.711 may be carried over Nb according to existing standards. Depending on the correct interpretation, there may be major or minor impact on the user plane support required for eTFO.

3.4 Impact on Mc Interface

What is the impact on the Mc Interface? The MSC Server needs to know the actual codec in use and the associated bandwidth. Is the architectural principle maintained that the MSC Server knows and controls the state of the MGW?
Is there any impact on the Nc Interface and BICC protocol?

Answer to 1st question:

Changes to Mc interface are not foreseen by the supporting companies. However if minor enhancements are needed to Mc interface they would likely be to the TFO package.

Answer to 2nd question:

In eTFO the MSC Server will not be aware of the actual codec in use between the MGWs, it will believe that the codec is still G.711 as configured at call set-up.

In eTFO the terminating MSC Servers will need to be involved in selecting the actual codec in use between the MGW and the mobile. For UMTS, as with TFO, the MSC Server passes the alternative codec list to the MGW using the H.248 protocol on the Mc interface. The MGW reports the TFO common codec negotiation result back to the MSC Server.

No impact on the Nc interface is expected.

There is no need to modify the bandwidth of connection when codec is changed. This can be thought of as analogous with AMR codec mode change or insertion. There is no system requirement to inform the Call Server of codec changes although eTFO does not preclude this.

It should be noted, however, that in the bearer independent core network it is the MSC server that selects and configures the FP to be used by the MGW. If IuFP needed to be changed, or a different FP needed to be used, then Mc interface and Nc interface impacts would need to be evaluated. However a FP change is only one of the options foreseen by the supporting companies.

3.5 Comparison eTFO/TFO with TrFO/TFO

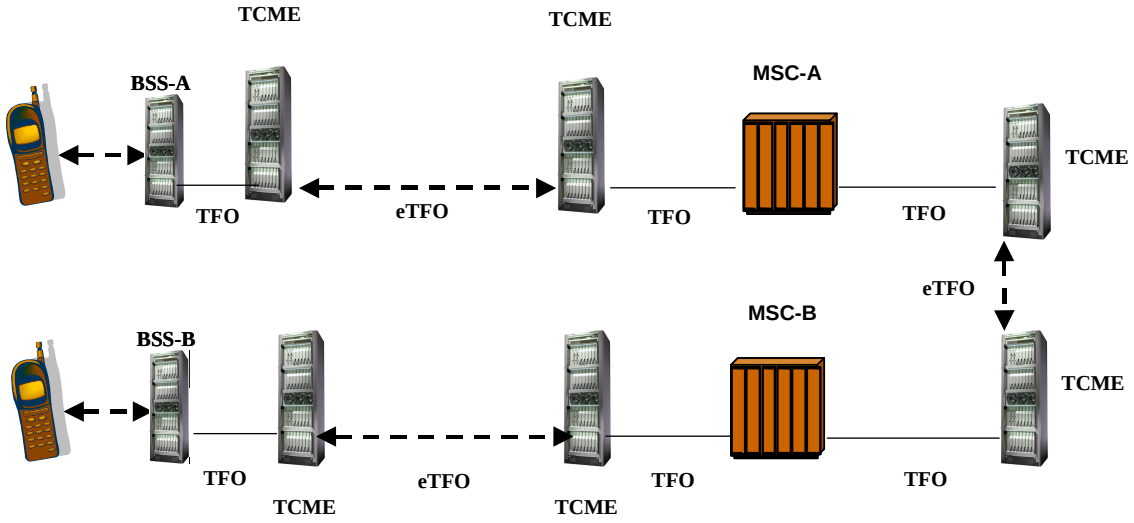
TrFO does not apply to TDM networks, however, interworking with TFO is possible at the MGWs. This may also be applied for interworking between GSM and UMTS.
Are there any scenarios which can be supported only by one of the two combinations, eTFO/TFO and TrFO/TFO, but not by the other one?
What are the benefits and drawbacks of eTFO/TFO interworking compared to the existing TrFO/TFO interworking?
This question was already raised at SA#18 and is considered a key question by a number of companies.

Answer to 1st question:
Two scenarios are described where eTFO could be used. Another scenario is described in 3.7.
Details of Scenario 1 have not been studied by SA2.

<u>Scenario 1: TCME – TFO Circuit Multiplication Equipment</u>

TCMEs are covered in TS 28.062 being described as a GSM specific Digital Circuit Multiplication Equipment. TCMEs reduce transmission costs without degrading speech quality by only transporting compressed speech and TFO control messages.

To obtain bandwidth savings with packet based TCMEs eTFO could be used. An example of a TCME call scenario is shown in figure 6



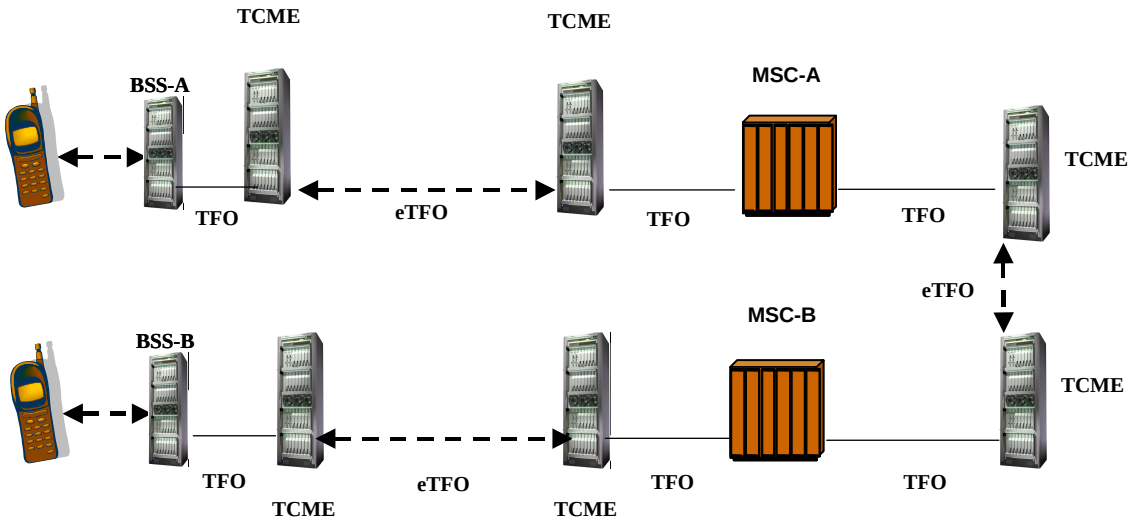


Figure 6. Packet based TCMEs

Scenario 2: Packet cores that do not support TrFO and/or OoBTC

Figure 7 shows a core network (MSC-A, MSC-B, MGW-A and MGW-B) that does not support TrFO or OoBTC. eTFO is implemented over the Nb interface. eTFO/TFO operates to provide bandwidth savings and reduced delay in addition to the improved speech quality that is achieved by tandem free operation.

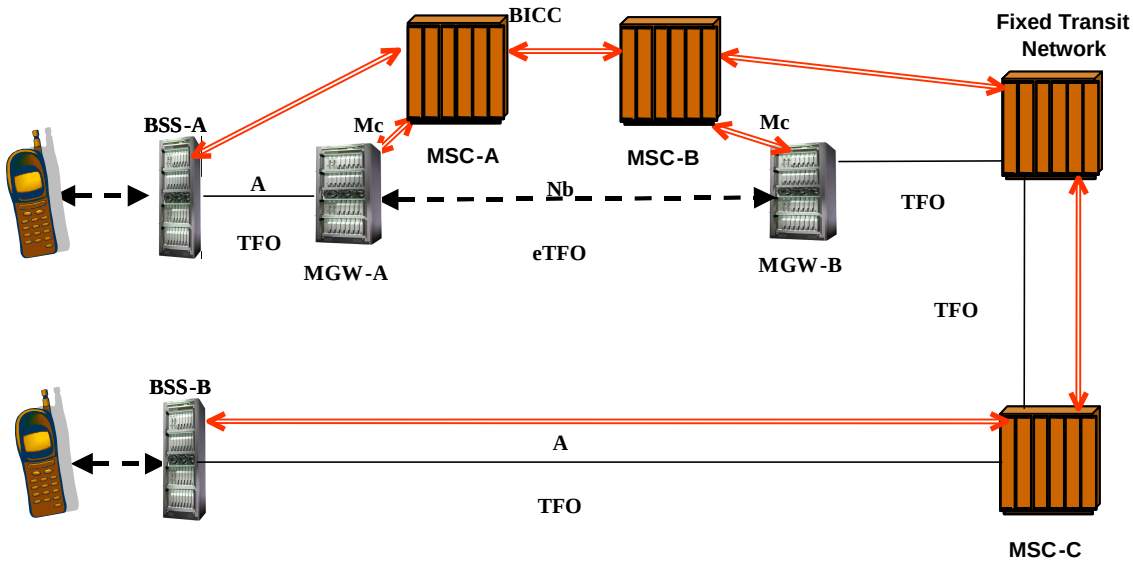


Figure 7. Packet cores that do not support BICC and/or OoBTC

:

Answer to the second question:

In the available time, SA2 could not agree on a comparison of TFO/TrFO with TFO/eTFO beyond the text contained in the summary below.
Note that input on these questions was available in S2-030866 and S2-030873.

3.6 Interworking eTFO/TrFO

It can be expected that there will be scenarios where interworking between TrFO and eTFO is required, e.g. at network borders or when eTFO is introduced. Is direct interworking between TrFO and eTFO possible at MGWs?

What are the procedures at the MGW during BICC procedures like the codec negotiation and codec modification procedure?

How do eTFO and TrFO interact in the same system?

How can it be ensured that in a certain section of the connection only OoBTC or eTFO is applied, but not both?

Answer to the 1st question: TrFO and eTFO interworking is necessary in cases where TrFO cannot be established between the originating and terminating MGWs of a connection. Figure 8 shows that eTFO establishment between two MGWs is analogous to TFO establishment. TrFO and eTFO interworking is analogous to TrFO and TFO interworking, which is defined in 23.153. Figure 5.5/3 "TFO support by OoBTC signalling" of 23.153 is adopted below to illustrate TrFO and eTFO interworking.

Summary of TrFO and eTFO interworking procedures:

1. TrFO is established individually between MSC and TSN in each access system. TSN and MGW in the UMTS system on the left side support codecs X, Y and Z. Codec X is selected. TSN and MGW in the UMTS system on the right side support codecs Y and Z. Codec Y is selected. See 23.153 for more details on TrFO codec negotiation.
2. After the call is setup and through connected, the two MGWs in the transit nodes start eTFO establishment. Codec lists are exchanged for codec negotiation. See message flows for mobile-mobile call eTFO establishment for details.
3. eTFO codec negotiation selects codec Z as the common codec. Selected codecs are modified by the TrFO establishments individually according to the TrFO codec modification procedures.

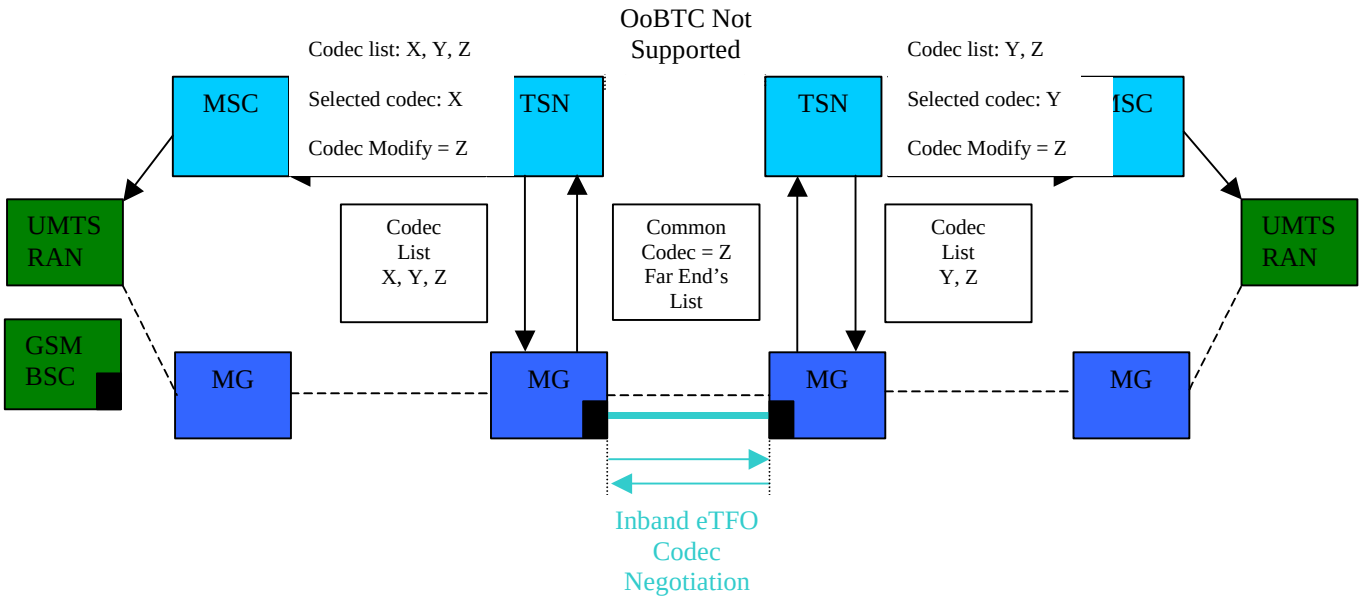


Figure 8: eTFO/TrFO interworking

Answer (to the second question):
During BICC codec negotiation, eTFO is not yet in place.

Answer to the 3rd question:

It is assumed that in this case the same system means within a single core network and that eTFO and TrFO are somehow both active throughout the length of this core network (between MGW at the A or Iu interface and the media gateway at the network edge of the core network).

It is not possible for TrFO and eTFO to establish at the same time as TrFO negotiates codec as part of the call set-up whereas eTFO will only be initiated after the call is set up. It is inherently not possible for apply both enhanced tandem free operation and transcoder free operation simultaneously as a tandem free operation retains a transcoder in the path.

Answer (to the fourth question):
With BICC, AMR compressed speech is used from the beginning of the call. TFO and therefore eTFO are operated only when G.711 is used at the beginning of the call. Therefore both OoBTC and eTFO cannot be used simultaneously.

3.7 Nodes involved in the eTFO/TFO negotiation

Which nodes are involved in the TFO/eTFO negotiation?

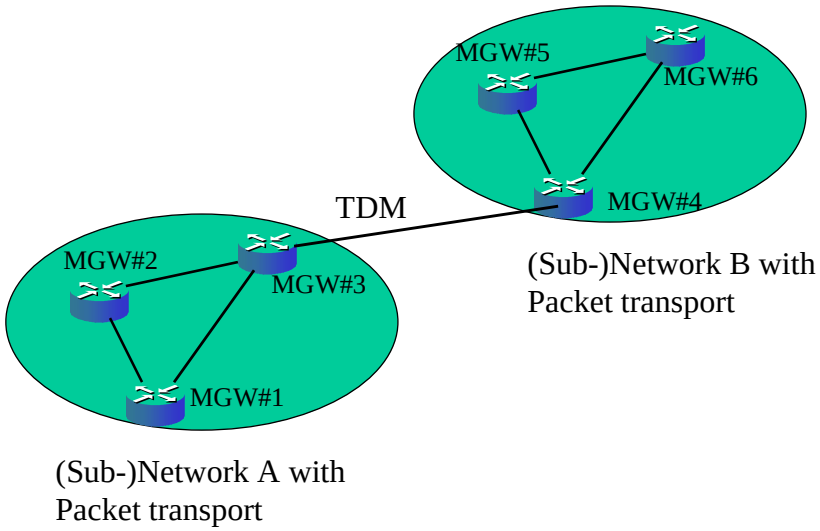
Answer:

Intermediate points which are required to perform the framing conversion between eTFO and TFO need to be eTFO aware. The MSC server is not involved in the eTFO/TFO interworking.

All intermediate nodes need to be IS responsive or IS active and (in case of ATM) support rt-VBR connections.

The end-to-end nature of TFO allows it to introduce TFO step-wise in new TRAUs at the edge of the network. It is not necessary that all TRAUs in the network support TFO, but TFO can be established between TFO enabled TRAUs (without a need e.g. to configure knowledge about other nodes). Indeed, this way TFO can be introduced gradually and works also across network borders.

In comparison, eTFO can not always only rely on end gateways to work its enhanced mode. Consider the following configuration of two packet networks (or sub-networks within a PLMN), which are connected via a TDM link. This is a quite common scenario in the introduction phase of packet technology in the CS domain.



Assume for example a voice call from MGW#1 to MGW#6, where both MGW#1 and MGW#6 are TFO enabled, but MGW#3 and/or MGW#4 do not support TFO. Then TFO can nevertheless be established between MGW#1 and MGW#6.
Now assume both MGW#1 and MGW#6 are upgraded to support eTFO, but still MGW#3 and MGW#4 do not support TFO or eTFO. Then both MGW#3 and MGW#4 will pass eTFO signalling towards MGW#6. As a result eTFO negotiation between both ends will succeed, however eTFO will fail because MGW#3 will not be prepared to receive the packets sent by MGW#1: MGW#3 would await G.711 and 64Kbit/s over Nb, and not understand the new frame format (and possibly framing protocol) negotiated via eTFO between MGW#1 and MGW#6
In the case when the intermediate MGW does not support eTFO protocol, it will drop the eTFO speech packets, eTFO will fail and fallback to G.711. Once in G.711 TFO can be established.
It may be possible to introduce an eTFO mechanism to support this scenario. This is FFS.

We conclude that in this scenario eTFO requires upgrades within the network and particularly at network borders to support eTFO.

The example in section 3.9 also shows that intermediate MGWs need to mediate between TFO and eTFO.

TFO uses the existing PCM encoding in TDM or packet bearer, eTFO requires an adaptation of the user plane.

3.8 Interworking with handover

According to [3], eTFO/TFO is also applicable in case of 2G-3G mobile-to-mobile calls. If the 2G subscriber performs an inter-BSC handover, usually the TRAU is changed and TFO is interrupted. In the packet gateway between 2G (TDM) and 3G (packet) network, the in-path-equipment will detect the loss of TFO. What happens then? Will the MGW (packet gateway) transcode between G.711 (used in the TDM network) and AMR (used in the packet network), or will the packet bearer be switched back to 64 kbit/s and G.711?

Answer:

The MGW can remain in eTFO, on the A interface TFO frames can be re-established. If the same speech codec is used after the handover the new TRAU will re-establish TFO almost immediately using the fast establishment after handover procedure. When AMR/AMR-WB are used the HO is announced and the MGW knows the reason for the loss of TFO synch.

More generally, what is meant by “fast fall back to regular tandem mode”? Does it mean that the packet bearer is switched back to 64 kbit/s and G.711? What are the criteria for such a fall back?
Answer:

Packet Bearer is always 64 kbit/s (rt-VBR in case of ATM), the codec is switched back to G.711.

The criteria for fallback is that something happens to the call topology such that eTFO or TFO needs to be interrupted (e.g. handover to a BSS with a different active speech codec). Transmission errors can also trigger the exit from eTFO.

In the fallback procedure, one end decides to go out of Tandem Free and it informs the other end. This is part of the existing TFO protocol.

3.9 Unsuccessful TFO/eTFO negotiation

In case of a 2G-3G mobile-to-mobile call, if the TFO/eTFO negotiation is unsuccessful, because the endpoints of the connection cannot agree on TFO compatible codecs, what will be the final configuration:

- 64 kbit/s, G.711 both in the packet network and in the TDM network, or
- AMR coded speech in the packet network and 64 kbit/s, G.711 in the TDM network with transcoding in the packet gateway?

For this scenario (2G to 3G) it will be AMR in the packet network and 64 kbit/s in the TDM portion. This assumes that the packet gateway is able to support speech coding and the eTFO procedures. If this is not the case, G.711 will be the codec used in both packet and TDM networks.

In the case that e.g. when the 3G-UE only supports UMTS AMR2 and the 2G-MS only supports FR and EFR, the packet gateway in between may terminate the inband negotiation towards both endpoints (e.g. it does not relay the supported codecs list received from the 2G TRAU, but instead sends its own supported codecs list containing the AMR to the transcoder in the 3G-MSC), so that AMR can be used in the packet network. There may be different parts of the call which end up with different codecs (but no more than 2). In this case what eTFO brings is that the G.711 portion is reduced. In this case eTFO does not add, nor remove, any more transcoding, but it brings bandwidth savings.

It will be a requirement of eTFO to ensure that multiple transcoding is avoided. This coordination will be achieved using the existing TFO message and specified in eTFO stage 3 specification.

In the example solution proposed above the intermediate gateway intervenes in the middle of a TFO negotiation between the two end points. Another option is for the intermediate gateway to step in after the end-to-end negotiation fails. Both options require a coordination mechanism between MGWs to avoid additional transcoding or race conditions respectively.

3.10 Support of Voice Quality Enhancements

According to [3], VQ features like Acoustic Echo Control (AEC) can be supported with TFO and eTFO, but not with TrFO. Why not?
If AEC is applied to the G.711 encoded speech in TFO, it is no longer tandem free operation; if AEC is applied to the AMR encoded speech, why can't it be applied also to the user plane in TrFO [TrFO break equipment]?

Answer:

When in eTFO, AEC is applied to AMR encoded speech. VQ can also be applied to the AMR encoded speed in a TrFO break equipment, which would need to be inserted. Thus in TrFO like in eTFO there would be more resources in the path than with TrFO without VQE. The additional processing requirements for AEC or any other VQ feature would be significantly less than would be required to transcode and are required for a necessity (to control echo). In terms of processing load for VQ features, there seems to be no significant difference between eTFO and TrFO.

3.11 Bearer Shortcut between eTFO endpoints?

In S4-020730, slide 12 seems to imply that direct bearers between eTFO endpoints may be established, bypassing intermediate MGWs in the original bearer.
Is that indeed an intention of eTFO? If so, are existing call control procedures capable to handle this situation?

Answer: No, this is definitely not intended (and an error in S4-020730).

3.12 Applicability to A-mode and Iu mode?

Does eTFO apply to both A-mode and Iu-mode? What is the difference to TrFO in that respect?

Answer:

Yes, eTFO, as TFO, can be used independent for both. Note that it is not intended to use eTFO frames at the A interface.
TrFO can be used with packet transport only and needs to be complemented with TFO for TDM transport. Furthermore, in case of a 3G-2G call, you can have TrFO from the 3G-MSC up to the 2G-MSC. Thus you can have at least the bandwidth savings inside the core network if TFO is not used.

3.13. Bandwidth Considerations

How big are the bandwidth savings achieved with eTFO?

With eTFO the bearer is not adapted to the codec in use, but bandwidth savings are achieved by statistical means. However, the probability to lose packets needs to be kept low in order to avoid that overbooking results in reduced speech quality. Thus the statistical mechanisms need to be applied carefully. As a result the bandwidth savings with eTFO would be less than with TrFO, where the bearer is adapted to the codec in use.
In summary, eTFO provides bandwidth savings compared to TFO, but they are less than with TrFO.