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**LTE;
Universal Mobile Telecommunications System (UMTS);
UICC power optimisation
for Machine-Type Communication (MTC)
(3GPP TR 31.970 version 16.0.0 Release 16)**



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Foreword

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The contents of the present document are subject to continuing work within the TSG and may change following formal TSG approval. Should the TSG modify the contents of the present document, it will be re-released by the TSG with an identifying change of release date and an increase in version number as follows:

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1 Scope

The present document has the objective to describe the power consumption caused by UICC when it is idle and identify the potential solutions to allow the reduction or removal of the UICC power supply in order to save power when the UICC is not required for long periods of time.

This document identifies conditions which might need to be applied to the UICC platform.

2 References

The following documents contain provisions which, through reference in this text, constitute provisions of the present document.

- References are either specific (identified by date of publication, edition number, version number, etc.) or non-specific.
- For a specific reference, subsequent revisions do not apply.
- For a non-specific reference, the latest version applies. In the case of a reference to a 3GPP document (including a GSM document), a non-specific reference implicitly refers to the latest version of that document *in the same Release as the present document*.

- [1] 3GPP TR 21.905: "Vocabulary for 3GPP Specifications".
 - [2] 3GPP TR 41.001: "GSM Release specifications".
 - [3] 3GPP TS 31.101 V13.0.0: "UICC-terminal interface; UICC-terminal interface; Physical and logical characteristics".
 - [4] 3GPP TS 31.102 V13.1.0: "Characteristics of the Universal Subscriber Identity Module (USIM) application".
 - [5] 3GPP TS 31.111 V13.1.0: "Universal Subscriber Identity Module (USIM) Application Toolkit (USAT)".
 - [6] ETSI TS 102 221 V13.0.0: "Smart Cards; UICC-Terminal interface; Physical and logical characteristics".
 - [7] ETSI TS 102 223 V12.3.0: "Smart Cards; Card Application Toolkit".
 - [8] 3GPP TS 22.368 V13.1.0: "Service requirements for Machine-Type Communications (MTC); Stage 1".
 - [9] 3GPP TR 23.887 V12.0.0: "Study on Machine-Type Communications (MTC) and other mobile data applications communications enhancements".
 - [10] 3GPP TS 23.682 V13.4.0: "Architecture enhancements to facilitate communications with packet data networks and applications".
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3 Definitions, symbols and abbreviations

3.1 Definitions

For the purposes of the present document, the terms and definitions given in 3GPP TR 21.905 [1] and the following apply. A term defined in the present document takes precedence over the definition of the same term, if any, in 3GPP TR 21.905 [1].

3.2 Abbreviations

For the purposes of the present document, the abbreviations given in 3GPP TR 21.905 [1], in 3GPP TS 31.102 [4] and the following apply.

An abbreviation defined in the present document takes precedence over the definition of the same abbreviation, if any, in 3GPP TR 21.905 [1].

4 Use cases

Use cases are described in Annex A of TS 22.368 [8]. Some examples are copied below:

Extra Low Power Consumption Use Case

For high mobility case, tracking MTC devices such as animal tracking MTC devices in natural world with high mobility require extra low power consumption because it is almost impossible to replace the battery or recharge the battery for animal tracking MTC device. Compared to the tracking devices installed in the cars and trucks because cars and trucks could generate electricity by themselves, extra low power consumption for these MTC devices is required.

For cargo tracking, the cargo with a tracking MTC device could move very fast such as on a train or lorry and could stand still such as in the dock before loading or unloading. It is not desired to either change its battery or replace battery during the transport period, so extra low power consumption MTC devices are also required.

For prisoner tracking MTC devices are already used by police, prisoners will not cooperate with police and would wish the MTC devices have flat batteries; therefore, extra low power consumption feature is required for these MTC devices. For the tracking MTC devices of elder people who have memory problem, children or pets, even the batteries of these MTC devices could be replaced or charged, however, considering the worst scenario – if they are missing, it requires the MTC devices with extra low power consumption and long working time in order to find them.

For low mobility case, the gas meter MTC devices must be battery powered. Extra low power consumption for gas MTC devices is much more critical than electricity meters.

Extra Low Power Consumption with Time Controlled MTC Devices Use Case

Time Controlled MTC Devices which send or receive data only at certain pre-defined periods may be operated in one or more modes that minimize power consumption.

An MTC Device may be operated in a mode where it is expected to receive non-periodic messages (e.g. emergency messages or notifications of altered access period as with the MTC Feature Time Controlled outside the time controlled periods. The MTC Device should minimize power consumption while in a mode to support this.

If the application requires the MTC Device to send or receive data within pre-defined periods and receive non-periodic messages outside these periods, operation at the lowest possible power consumption level to extend battery life should be achieved.

Such use cases justify the overall system requirement present in TS 22.368 [8]:

The system shall provide mechanisms to lower power consumption of MTC Devices.

Some solutions to lower the overall power consumption in such scenarios are already defined within 3GPP, as described in TR 23.887 [9] clause 7. These include:

- Extended DRX cycle, introduced in Rel-13, as described in TS 23.682 [10] clause 4.5.13.

5 Power considerations related to the UICC

5.1 Causes of power consumption related to the UICC

5.1.1 Introduction

During the power cycle of the ME, there are only some short periods of time during which the UICC is actively used by the terminal and that activity normally occurs in bursts. Examples of this include:

- The ME reads configuration parameters set by the MNO and stored in the UICC
- The ME performs authentication command
- The ME reads data stored in the UICC by the end user (i.e. phonebook or SMS)
- The ME writes data to the UICC
- Proactive sessions, as defined in TS 31.111 [5]
- Toolkit events, as defined in TS 31.111 [5]

During the rest of the time, the UICC is not actively used by the terminal. There are three distinct causes of power consumption that are related to the presence of the UICC that contains a USIM when not actively used.

5.1.2 Presence detection polling

The presence detection mechanism is defined in ETSI TS 102 221 [6] clause 14.5.2 and referenced by 3GPP TS 31.101 [3]:

If an application present on the UICC has the requirement to ensure that the UICC has not been removed during a card session the following procedure applies. The terminal sends, at frequent intervals, a STATUS command on the UICC-terminal interface. The STATUS command shall be issued within a period of inactivity on the UICC-terminal interface. [...] This procedure shall be used in addition to a mechanical or other device used to detect the removal of a UICC.

According to TS 31.102 [4] clause 5.1.9, presence detection polling is required by the USIM only in case of a call, including active PDP context, and can be suspended if the ME has not exchanged any data with the network within a 30s period of inactivity on the UICC-ME interface.

The ME may suspend the UICC presence detection based on STATUS commands in case it has an active PDP context or an active EPS bearer context, but has not exchanged any data with the network within a 30s period of inactivity on the UICC-ME interface, and resume it as soon as data is exchanged with the network, sending immediately a new STATUS command.

As a consequence of changes agreed in Release 12 as part of the MTCe-UEPCOP-CT Work Item, the presence detection polling is not a concern for devices that are not actively exchanging data with the network.

5.1.3 Proactive polling

The proactive polling mechanism is defined in ETSI TS 102 221 [6] clause 14.6.2 and referenced by 3GPP TS 31.101 [3]:

During idle mode the terminal shall send STATUS commands to the UICC at intervals no longer than the interval negotiated with the UICC (see TS 102 223 [7]). During a call the UICC presence detection applies. The default value for the proactive polling is the same as for the presence detection procedure.

The interval of the proactive polling can be negotiated between UICC and ME:

- the UICC can completely disable proactive polling using the POLLING OFF proactive command, defined in TS 31.111 [5];

- the UICC can mandate a longer polling interval using the POLL INTERVAL proactive command, defined in TS 31.111 [5];
- the ME can request an optimal polling interval using the Poll Interval Negotiation procedure, defined in TS 31.111 [5].

In a deployment where power saving is very important, it is reasonable to expect that polling is disabled by the UICC or that at least an optimal polling interval requested by the ME is negotiated. As a consequence, the power consumption related to proactive polling is not a concern for those devices.

5.1.4 Power absorbed by the UICC in idle state

The UICC consumes power at all times, also when the clock is stopped and the UICC is in idle state. This power consumption is summarized in table 1 for different classes of UICC, based on values indicated in ETSI 102 221 [6]:

Table 1: power when the clock is stopped

Class	Clause	Power consumption
Class "B"	5.2.1	When the UICC is in idle state, the current consumption shall not exceed 200 μ A at 1 MHz at +25 °C. When the UICC is in clock stop mode and no other interface is active, the current consumption shall not exceed 100 μ A at +25 °C.
Class "C"	5.3.1	When the UICC is in idle state, the current consumption shall not exceed 200 μ A at 1 MHz at +25 °C. When the UICC is in clock stop mode and no other interface is active, the current consumption shall not exceed 100 μ A at +25 °C.

Measurements taken in the field on UICC cards without special applications (for example, payment applications) show a consumption of about 15 μ A in clock stop mode. This value is used as reference in the rest of this document.

In addition to the numbers indicated above, note that the overall power consumption of the ME to provide the necessary current to the UICC is significantly higher, as it needs to keep the voltage regulator active.

Even if these numbers seem to be low, they become significant over a large period of time, which is a common use case for some devices.

5.2 Comparisons

5.2.1 Introduction

The objective of this clause is to compare the power consumed by the terminal in two distinct cases: during the initialization of the UICC and an attach procedure to the network, and the while keeping the UICC in idle mode without exchanging any APDU.

The goal of this comparison is to define the best strategy from a power perspective for a UE that only needs to exchange data with the network rarely.

For this comparison, it will be assumed a UICC card with only a USIM, as commonly seen in commercial deployments for devices that do not have voice capabilities.

5.2.2 Power required to initialize a UICC

The amount of time taken by the ME to initialize a UICC and the USIM application in it varies significantly, depending on the number of factors, including:

- services that are enabled in the USIM application (as the number of EFs that needs to be read is directly related to the initialization time);

- capabilities of the terminal (for example, a device without voice capabilities might not cache the phonebook stored in the UICC)
- speed of the ISO interface
- delay of the UICC to respond back for APDU requests

An overall initialization time of about 2 seconds can be considered as an average delay for devices that initialize a UICC containing a simple USIM, without many additional services.

During this delay, the power consumption of the UE is the sum of two components:

- Power consumption of the USIM
- Power consumption of the ME

In the absence of specific negotiation with the UICC using the TERMINAL CAPABILITY command, which is the most common case in the market today and most likely scenario for M2M terminals, the USIM has a maximum power consumption of 10 mA, as specified by ETSI TS 102 221 [6].

The estimate of the power consumption of the ME is not simple, as it vary greatly and has evolved rapidly in the last years. Anyway, for the purpose of this document, a power consumption of 100 mA will be considered.

5.2.3 Comparison

The following clause analyzes the power consumption related to the UICC for these two approaches:

- terminal keeps the UICC powered up in clock stop mode and the UICC consumes 15 μ A for the entire duration
- UE switches off the UICC and re-activates it only when needed

The comparison is done for two separate cases, respectively with duration of 1 day and 1 week.

The additional power consumption of the ME is not considered in table 2, as it would be the same in both cases.

Table 2: Comparison of power consumption

	1 day		1 week	
	UICC powered up in clock stop mode	UICC switched off	UICC powered up in clock stop mode	UICC switched off
USIM	15 μ A * 24 h = 0.360 mAh	10 mA * 2 s = 0.005 mAh	15 μ A * 168 h = 2.520 mAh	10 mA * 2 s = 0.005 mAh
ME	0 mAh (see note 1)	100 mA * 2 s = 0.055 mAh	0 mAh (see note 1)	100 mA * 2 s = 0.055 mAh
Total	0.360 mAh	0.060 mAh	2.520 mAh	0.060 mAh
NOTE: This value assumes the best case without any leak in the ME to keep the UICC powered up.				

In addition to power consumed for the UICC, there is also a difference in the power required for signalling over the network. An accurate estimate of the power required for this is difficult to perform: it varies greatly based on network conditions and delays, and it might also change a lot for each product. Anyway it is reasonable to consider them similar and it should be noted that this contribution to the total power becomes less and less relevant with the increase of the duration.

5.2.4 Conclusions

From the comparison above, it is evident that there is no incentive from a power perspective to keep the UICC powered up in clock stop mode.

5.3 Objective

The objective of this document is to define a UICC platform level solution that can be used to reduce the power consumption of the UE when the UICC is not actively used, removing the power component caused by the UICC in idle state.

The document focuses on M2M use cases. In this context, it is assumed that the UICC has limited functionalities and does not include applications often seen for smartphones (for example, for mobile payments).

6 Proposed solution

6.1 UICC suspension

6.1.1 Overview

3GPP has already agreed text to allow the UE to switch off the UICC card as described in 3GPP TS 31.102 [4] clause 5.1.10 in order to reduce power consumption, as per previous sections. This has two impacts:

- The ME needs to re-initialize the UICC and the USIM from the beginning when the USIM is required
- The UICC would lose its context, which could potentially have impact on the applications in the UICC

For these reasons, it is proposed a solution where the UICC can be suspended in a way that allows the ME to remove the power, while still keeping the status of the card.

It is clear that a solution where the UICC is suspended needs to be specified at platform level, so it is appropriate that such solution is defined by ETSI SCP.

The following section describes a high-level proposal as discussed in CT6. The final solution might be different from what is described below, as long as it meets the overall requirements discussed in this document.

6.1.2 New commands

6.1.2.1 Introduction

The proposal is to introduce two new commands in the UICC platform, as specified below:

- SUSPEND UICC
- RESUME UICC

6.1.2.2 SUSPEND UICC

6.1.2.2.1 Functional description

This function is used to store the internal status of the UICC so that power supply to the UICC can be switched off. When the UICC receives the command, it stores the complete UICC status to a non-volatile memory. The UICC status includes at least the following items:

- status of selected NAA on each logical channel
- security conditions for each NAA
- selected EF and record for each logical channel
- status of toolkit applications

The ME does not issue the command if the UICC suspension mechanism is not indicated as supported by the UICC (for example, by means of a bit in the EF_{UMPC}).

The UICC generates a Resume information and stores it with the complete status to its non-volatile memory. The method of generation and the length of the Resume information need to be defined.

The UICC deletes or invalidates the saved status if it receives any APDU after responding to the SUSPEND UICC command. This implies that the UICC may have at most one stored status at any time.

NOTE: the execution of this command might take a significant amount of time.

The input parameters of the function include at least the following items:

- Maximum duration of the suspension proposed by the ME

The output parameters of the function include at least the following items:

- Negotiated duration of the suspension decided by the UICC
- Resume information

6.1.2.3 RESUME UICC

6.1.2.3.1 Functional description

This function is used to restore the status of the UICC that was previously stored to non-volatile memory of the UICC. The UICC shall delete the stored UICC status after execution of the command, irrespective of the result.

The ME does not issue this command if the UICC suspension mechanism is not indicated as supported by the UICC (for example, by means of a bit in the EF_{UMPC}).

The UICC deletes or invalidates the stored status if a normal initialization is performed by the UICC. For example, the UICC might delete or invalidate the stored status if it receives a TERMINAL PROFILE command or any SELECT by DF name command. The UICC rejects the RESUME UICC command if it does not have a valid status to resume (for example, returning status word '6985').

The UICC compares the Resume information passed by the terminal with the key stored in the non-volatile memory. The UICC responds with an error if the Resume information passed by the ME does not match (for example, returning status word '6982'). The UICC restores the previous status and return '9000' if the Resume information passed by the ME is validated.

NOTE: the execution of this command might take a significant amount of time.

The input parameters of the function include at least the following items:

- Resume information

7 Considerations on proposed solutions

7.1 UICC suspension

7.1.1 Introduction

The following clauses describe the considerations related to the UICC suspension proposal.

7.1.2 Security

The main security objective of the feature is to prevent that a UICC can be suspended, removed from the ME and then resumed in a separate ME, where it can be used bypassing the initialization and, potentially, the PIN verification. The

"Resume information" described in the sections above solves the problem, allowing only the ME that has the "Resume information" to be able to issue the RESUME UICC command successfully.

The alternative where the UICC is powered down and re-initialized when needed by the terminal should be considered less secure, because it is applicable only to the case where PIN is disabled. For this reason, that creates an incentive to keep the PIN disabled in the USIM.

7.1.3 Toolkit

7.1.3.1 Proactive UICC session

The proactive UICC session is defined in ETSI TS 102 223 [7] clause 3.1:

proactive UICC session: sequence of related CAT commands and responses which starts with the status response '91XX' (proactive command pending) and ends with a status response of '90 00' (normal ending of command) after Terminal Response

The suspension of the UICC during a proactive UICC session might potentially lead to problems to the application, especially if there are time-sensitive operations. Moreover, even if the interface between ME and UICC might be idle during a proactive UICC session, it is logically incorrect to assume that entire UICC is idle.

For this reason, the solution should prevent the suspension of the UICC during a proactive UICC session.

7.1.3.2 BIP session

BIP is used to establish a data connection between the UICC and a server on the network, using the connectivity provided by the ME. It is possible that the proactive UICC session is ended during an active BIP session (i.e., while waiting a response from the network).

In order to avoid any impact on network elements, the SUSPEND mechanism should not be used if any BIP channel is opened.

NOTE: these considerations do not apply for the OPEN CHANNEL related to UICC Server Mode.

7.1.3.3 Timers

The UICC is able to manage timers running physically in the terminal with the proactive command TIMER MANAGEMENT and be informed when the timer expires. Timers are normally used for time-sensitive operations.

The solution should not have impact on the handling of timers. The solution should:

- Either prevent the UICC suspension when one or more timers are running,
- or guarantee that UICC is resumed before any timer expires.

7.1.3.4 Other events

In the case where the ME needs to send an ENVELOPE command to the UICC when it is suspended, the ME should immediately resume the UICC and then send the ENVELOPE.

7.1.4 Internal events

It is possible that specific applications (e.g. USIM, ISIM, CAT applications) inside the UICC can not tolerate the suspension of the UICC in a specific state or might need to perform specific operations before the UICC is suspended. For this reason, the solution should have a mechanism to inform the applications in the UICC about the SUSPEND command and allow each interested application to return a temporary error or reject it. A temporary error gives to the ME the indication that SUSPEND can be retried later. A mechanism to avoid a repeated trial and error approach by the ME should be considered (e.g. by allowing the UICC to indicate a period of time after which the ME may retry successfully to issue a SUSPEND command or a mechanism for the UICC to explicitly state it is ready to be suspended).

7.1.5 Duration

It is considered useful for the UICC to know the estimate of the duration of the suspension. The ME might not be in a position to know it exactly, as this might vary based on external inputs, but the ME is able to provide the maximum duration.

The UICC should be able to negotiate such duration, proposing a smaller value, if it has the need to be resumed at a specific time to perform time-critical activities (for example, report to a server at a certain time).

7.1.6 Impact on ME

The ME should not use any of the values contained in the UICC and previous cached (e.g., value of IMSI) until it has successfully resumed the UICC.

The ME should also maintain the status related to toolkit operations. This includes maintaining the poll interval negotiated with the UICC, the list of events received in the last SET UP EVENT LIST proactive command and the toolkit menu received in the last SET UP MENU proactive command. These should be removed from the ME only in case of failure to resume the UICC successfully.

8 Conclusions

8.1 UICC platform

A solution for the UICC suspension requires support by the UICC platform. For this reason, ETSI SCP should be requested to provide the required commands.

8.2 Impact on 3GPP network access applications

Based on the solution adopted by ETSI SCP, 3GPP would need to further expand its specifications to incorporate necessary changes to allow a UICC containing 3GPP network access applications (for example, USIM and ISIM) to be suspended. The overall impact will be assessed when the platform-level changes are available.

Annex A: Change history

Change history							
Date	TSG #	TSG Doc.	CR	Rev	Subject/Comment	Old	New
2016-03	CT#71		-	-	First publication of the Technical Report.		14.0.0
2018-07	SA#80				Automatic upgrade to Rel-15	14.0.0	15.0.0
2020-07	CT#88e	-	-	-	Update to Rel-16 version (MCC)	15.0.0	16.0.0

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