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3RD GENERATION PARTNERSHIP PROJECT 2 "3GPP2"

# *cdma2000 M2M Numbering Recommendations System Requirements Document*

## Revision History

| Revision | Description of Changes | Date |
|---|---|---|
| Rev 0 v1.0 | Initial publication release | 14 October 2011 |

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## Foreword

This foreword is not part of this specification.

The document has been prepared by the 3GPP2 SC (Steering Committee) M2M Numbering AdHoc under charter from the 3GPP2 SC.

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# 1 INTRODUCTION

## 1.1 Overview

This report is a System Requirements Document that analyzes issues associated with M2M Numbering and provides recommendations from the 3GPP2 SC M2M Numbering AdHoc. This report contains normative requirements and suggested normative requirements.

M2M refers to "machine-to-machine" communications – communications for devices that normally exchange data without human intervention and which, in the context of this report, have at least one cdma2000®[1] operational mode.

## 1.2 Scope

This document is focused on the numbering, identification, and addressing aspects of M2M technologies and services using 3GPP2 specifications. The following activities were executed in the development of this document:

- Consideration of issues related to M2M numbering and addressing schemes;
- Investigation of global M2M numbering issues and liaison with industry M2M committees, relevant stakeholders and fora;
- Determination of M2M numbering impacts regarding addressing (e.g., E.164 MSISDNs, IMSI) and device identification (e.g., IMEI, MEID) in a fashion that is complementary to the work of other groups;
- Consideration of other terminology for M2M (e.g., (MTC) Machine Type Communications and (SDC) Smart Device Communications);
- Evaluation of proposals for M2M numbering resources while identifying numbering methods that consider potential negative impacts on legacy numbering and back office systems.

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[1] cdma2000® is a trademark for the technical nomenclature for certain specifications and standards of the Organizational Partners (OPs) of 3GPP2. Geographically (and as of the date of publication), cdma2000 is a registered trademark of the Telecommunications Industry Association (TIA-USA) in the United States.

Terminology used in this  report, unless otherwise specified, is limited to the context of cdma2000 protocols.

## 1.3 Document Conventions

"Shall" and "shall not" identify requirements to be followed strictly to conform to this document and from which no deviation is permitted. "Should" and "should not" indicate that one of several possibilities is recommended as particularly suitable, without mentioning or excluding others, that a certain course of action is preferred but not necessarily required, or that (in the negative form) a certain possibility or course of action is discouraged but not prohibited. "May" and "need not" indicate a course of action permissible within the limits of the document. "Can" and "cannot" are used for statements of possibility and capability, whether material, physical or causal.

## 1.4 References

The following informative references were used in the preparation of this report:

[1] 3GPP2 C.S0024-B v3.0 cdma2000 High Rate Packet Data Air Interface Specification.  September 2009.

[2] Ericsson North America - Geoff Hollingsworth.  Presentation to the CDG webinar on Smart Wireless Devices entitled "Perspectives on M2M".  17 January 2011. http://www.cdg.org/news/events/webcast/110310_smart_devices_service/2_Ericsson-Hollingworth_M2M_Perspectives_PA7av2.pdf

[3] IETF RFC 4282 The Network Access Identifier. December 2005.

[4] IEEE Guidelines for 64-bit Global Identifier (EUI-64) Registration Authority. http://standards.ieee.org/develop/regauth/tut/eui64.pdf

[5] 3GPP2 SC.R4001-0 v3.0 Global Wireless Equipment Numbering Administration Procedures.  3GPP2.  April, 2011.

[6] 3GPP2 SC.R4002-0 v7.0 GHA Assignment Procedures for MEID and SF_EUIMID.  3GPP2.  April, 2011.

[7] 3GPP2 SC.R4003-0 v1.0 Expanded R-UIM Numbering Administration Procedures. 3GPP2.  June 2007.

[8] 3GPP2 SC.R4004-0 v2.0 User Identification Mobile ID Manufacturer's Code Assignment Guidelines and Procedures. 3GPP2.  May 2010.

[9] GSMA TS.06 IMEI Allocation and Approval Guidelines Version 6.0. July 2011.

[10] MBI Oversight Council - MIN Block Identifier (MBI) Assignment Guidelines and Procedures Version 6.00. April 2008. https://mbiadmin.com/MBI/guidelines.jsp

[11] IFAST International Roaming Mobile Identification Number (MIN) (IRM) Assignment Guidelines and Procedures Version 5.4. April 2007. http://www.ifast.org/files/GuidelinesMay2007/IRM Guidelines v5.4.pdf

[12] IFAST System Identification Number (SID) Assignment Guidelines and Procedures Version 2.2. April 2007. http://ifast.org/files/GuidelinesMay2007/IFAST SID Guidelines r2.2.pdf

[13] ITU-T E.164 The international public telecommunication numbering plan. November 2010.

[14] ITU-T E.118 The international telecommunication charge card. May 2006.

[15] ITU-T E.212 The international identification plan for public networks and subscriptions. May 2008.

[16] TIA TR-45 Electronic Serial Number Manufacturer's Code Assignment Guidelines and Procedures. December 2009.

[17] IETF RFC 2460 Internet Protocol, Version 6 (IPv6). December 1998.

[18] IETF eRFC 791 Internet Protocol. September 1981.

[19] IETF RFC 2784 Generic Routing Encapsulation (GRE). March 2000.

[20] IETF RFC 2865 Remote Authentication Dial In User Service (RADIUS). June 2000.

[21] ARN IPv4 Depletion, IPv6 Adoption. February 2011. https://www.arin.net/knowledge/v4_deplete_v6_adopt.ppt

[22] 3GPP2 C.S0005-E v3.0 Upper Layer (Layer 3) Signaling Standard for cdma2000 Spread Spectrum Systems. June 2011.

[23] 3GPP2 C.S0087-A v1.0 E-UTRAN – cdma2000 HRPD Connectivity and Interworking: Air Interface Specification. April 2011.

[24] 3GPP2 C.S0098-0 v1.0 cdma2000 Extended Cell High Rate Packet Data Air Interface Specification. January 2011.

## 1.5 Assumptions

The following assumptions are considered reasonable as of the date of this report but cannot be fully validated as they depend on the future evolution of M2M:

1. Backwards compatibility with existing cdma2000 specifications is expected to be maintained,
2. Existing Numbering Administration and related guidelines/procedures (e.g., ESN, MEID, UIMID, IMEI are not intended to be affected or require modifications as a result of recommendations in this document).
3. Industry projections estimate that 50 billion M2M devices will be deployed globally using some or all of the available access technologies by the year 2020.[2] In the most extreme case, identifiers used in cdma2000 systems that simultaneously support legacy and M2M devices, should accommodate at least 60 billion devices.
4. The majority of M2M devices in cdma2000 networks will never need to make circuit or packet voice, TDD, or analog modem calls and therefore will not need an MDN for this purpose.
5. It is reasonable for operators to use MIN or IMSI to address SMS if they have insufficient MDNs for all M2M devices.
6. It is reasonable to utilize a mediation device in the network when M2M devices use SMS to communicate, particularly when communications may be between a cdma2000 device and a 3GPP device.
7. There are no services beyond circuit switched (voice, circuit data, TTY) and direct cdma2000-to-3GPP SMS that require the use of an MDN.

# 2 Acronyms, Abbreviations, and Terminology

| ACRONYM/ ABBREVIATION | DEFINITION |
|---|---|
| 3GPP2 SC | Third Generation Partnership Project 2 Steering Committee |
| AAA | Authentication, Authorization, and Accounting |
| Card ID | UIMID or LF_EUIMID (with pUIMID) or SF_EUIMID (with pUIMID). |

| ACRONYM/ ABBREVIATION | DEFINITION |
|---|---|
| cdma2000 Communications Module | A module that can support one active cdma2000 radio connection. |
| cdma2000 M2M Device | An M2M device that supports M2M services over one or more cdma2000 radio technologies. |
| cdma2000 Packet Data | Packet data provided over one (1) or more of the following air interfaces: cdma2000 1x [22], HRPD [1], eHRPD [23], xHRPD [24]. |
| CSIM | cdma2000 Subscriber Identity Module |
| DNS | Domain Name System |
| ESN | Electronic Serial Number |
| EUIMID | Expanded UIMID. Either SF_EUIMID or LF_EUIMID where SF = short form and LF = long form. |
| GSMA | GSM Association |
| ICCID | International Telecommunication Charge Card ID |
| IFAST | International Forum on ANSI-41 Standards Technology |
| IMEI | International Mobile Equipment Identity |
| IMSI | International Mobile Station Identity |
| IP | Internet Protocol |
| IRM | International Roaming MIN |
| ITU | International Telecommunications Union |
| M2M | Machine-to-Machine |
| M2M Device | A device capable of replying to requests for its data or capable of transmitting its data autonomously. In subsequent sections of this document, the term “M2M device” is understood to mean a “cdma2000 M2M Device”. |
| MAC | Media Access Control |
| MBI | MIN Block Identifier |
| MCC | Mobile Country Code |
| MDN | Mobile Directory Number |
| MEID | Mobile Equipment Identity |
| MIN | Mobile Identification Number |
| MIN-Based IMSI | MIN with an IMSI-like prefix. |
| MNC | Mobile Network Code |
| MSIN | Mobile Subscription Identification Number |
| NAI | Network Access Identifier |
| NID | Network Identification Number |
| PMIP | Proxy Mobile IP |

| ACRONYM/ ABBREVIATION | DEFINITION |
|---|---|
| R-UIM | Removable User Identity Module |
| RAT | Radio Access Technology |
| SID | System Identifier |
| SIM | Subscriber Identity Module |
| TDD | Telecommunications Device for the Deaf |
| TIA | Telecommunications Industry Association |
| True IMSI | An IMSI containing an allocated MNC and MSIN rather than embedding a MIN. Also known as IMSI_T. |

## 3 Objectives of the M2M Numbering Scheme

The objectives of the cdma2000 M2M Numbering scheme that must be supported by 3GPP2 may include, but are not limited to, the following:

- Number of devices that may need to be addressed over time,
- Device Identifier requirements,
- Subscription Identifier requirements,
- Logical Addressing Identifier requirements, and
- Potential addressing schemes.

## 4 Identifier Matrix

The following cdma2000 identifiers were considered during the development of this document.

| Identifier | Attributes | Comments |
|---|---|---|
| **Hardware Identifiers** | | |
| ESN | 32 bits | Original hardware identifier standard used for analog and cdma2000 devices. Now largely exhausted and new applications have not been accepted since 30 June 2010. |
| IMEI | 14 decimal digits | Used by devices with a 3GPP operational mode. Administration controlled by GSMA. |
| MEID | 14 hexadecimal digits "also multimode 14 decimal digits" | The new hardware identifier standard used for cdma2000 devices. Administration is controlled by TIA. |

| Identifier | Attributes | Comments |
|---|---|---|
| **Interface Identifiers** | | |
| MAC | 64 bits | The expanded version of the MAC address known as EUI-64[4]. Permanently assigned to a specific protocol interface device. |
| IPv4 Address | 32 bits | May be temporarily or permanently assigned to an interface. May be subject to translation within the network. Not necessarily globally unique. |
| IPv6 Address | 128 bits | May be temporarily or permanently assigned to an interface. May be subject to translation within the network. |
| **1X Subscription Identifiers** | | |
| MIN | 10 decimal digits | The subscription identifier used by most cdma2000 1x networks (sometimes called “MIN-based IMSI”). Administered by the MBI Administrator (North America) and by IFAST (other continents and data-only uses). |
| IMSI | 15 decimal digits | Defined for cdma2000 in 1994. MCC (first 3 digits) administered by ITU and MNC (next 2 or 3 digits) administered nationally.[15] |
| **Packet Data Subscription Identifier** | | |
| NAI | Up to 72 characters | Network Access Identifier[3] |
| **Packet Data External Routing Identifier** | | |
| Public IPv4 | 32 bits | A public IPv4 address can be assigned to a device and used to route packets to it (assuming that Mobile IP or other mobility protocols are implemented). |
| Dynamic DNS | Domain Name | A mobile can be assigned an individual domain name with the DNS updated whenever the mobile changes local IP address (e.g., when roaming). |
| **Telephone/Mobile Directory Numbers** | | |
| MDN | Up to 15 decimal digits | Phone numbers can be up to 15 digits long subject to local numbering plan restrictions on the number of digits and range of individual digits (sometimes less than ‘0’-‘9’). |

| Identifier | Attributes | Comments |
|---|---|---|
| **Smart Card Identifiers** | | |
| UIMID | 32 bits | Allocation derived from the ESN numbering pool. Applications for new assignments ceased on June 30, 2010. |
| SF_EUIMID | 56 bits/14 hex digits | Allocated from the MEID numbering resources by the TIA. One choice to replace the UIMID. |
| LF_EUIMID | 72 bits/18 decimal digits | This is the ICCID when used to replace the UIMID. |
| ICCID | 72 bits/18 decimal digits | This ITU-standardized identifier is found in virtually all telecom cards dating back to the GSM SIM card. It can be assigned nationally using "89" and the ITU-T landline country code as a prefix. |
| **Visited/Serving System Packet Data Identifiers** | | |
| Public IPv4 | 32 bits | A globally unique IP address that can be temporarily assigned to a mobile when roaming. |
| Private IPv4 | 24 bits (approx) | An IP address that is used within a single network. Although the address is 32 bits long only about 24 bits are available for private addresses. |
| IPv6 | 128 bits (3E38) | Defined in the mid-1990s to expand the number of available IP addresses in the Internet. |
| GRE Key | 32 bits | An identifier for a tunnel between different cdma2000 packet data network elements such as (e)AN, (e)PCF and PDSN/HSGW. GRE Keys are private to an individual IP network provider.[19] |

| Identifier | Attributes | Comments |
|---|---|---|
| **Base Station Identifiers** | | |
| SID | 15 bits | A number assigned by IFAST or a national regulator that should be uniquely assigned to an operator to identify a zone of coverage containing from between 1 and all of the operator's base stations. |
| NID | 16 bits | An extension to the SID that can be assigned by an operator to identify base stations covering areas smaller than identified by a single SID, down to a single base station. |
| MCC | 3 digits | A number assigned by ITU-T that may be used to identify the country from which a base station is authorized to transmit. |
| MNC | 2 or 3 digits | A number assigned nationally to an operator that is an extension to the MCC that can identify the operator or a large region within the operator's network. |
| SubnetID | 128 bits | A number used by an operator that is used to uniquely identify an (e)HRPD system.[1] |

# 5 Problems Definition and Solution Options - 1x Subscription Identifiers

This section identifies problems with and potential solutions for applying current 1x subscription identifiers to M2M numbering applications.

In this section, **SR-S-1x-xx** refers to a Suggested Requirement that should be considered when developing cdma2000 1x subscription identifier requirements for cdma2000 development activities.

## 5.1 <u>MIN Exhaustion</u>

The MIN resource can support 10 billion identifiers although only approximately 3.6 billion are allocated for use outside North America (by IFAST). This means that the MIN (MIN-based IMSI) will last for some considerable time in the future but not necessarily as long as technologies that use MIN.

MIN exhaustion is not imminent but devices that may be embedded in the field for a long time should be adaptable to be re-provisioned with IMSI in the future.

**SR-S-1x-01: All cdma2000 M2M devices that require a 1x Subscription Identifier should support provisioning with true IMSI.**

**SR-S-1x-02: M2M devices that may roam and that are provisioned with true IMSI should also be provisioned with MIN and MIN-based IMSI.**

### 5.2 Identifier Global Uniqueness

Every M2M device that may roam or that may access a system that accepts incoming global roamers should have a globally unique subscription identifier during its operation. There may be some special circumstances that allow non-unique identifiers to be used.

Therefore there are no new requirements. For the purpose of estimating the potential numbering exhaustion related to subscription identifiers, global uniqueness of every subscription identifier is assumed in this report.

### 5.3 Multiple Subscriptions

Under some circumstances, cdma2000 M2M Communication Modules may require multiple 1x subscription identifiers (e.g., to minimize roaming) even though the module will only support one access (using one of the subscription identifiers) at any one time.

### 5.4 Multiple Simultaneous cdma2000 Accesses

A cdma2000 M2M Device may contain multiple cdma2000 M2M Communication Modules. In this case each cdma2000 M2M Communication Module may use a separate 1x Subscription Identifier to provide multiple simultaneous accesses within the cdma2000 M2M Device.

## 5.5 Multiple Access Subscription Identifiers for different Access Technologies

In the case where an M2M Communications Module supports more than one access technology (e.g., cdma2000 (HRPD), 3GPP (LTE), WLAN), the following scenarios are supported:

- The M2M Communications Module uses the same access subscription over all access technologies. In this case, the same M2M access subscription identifier is used over all access technologies.
- The M2M Communications Module uses different access subscription over different access technologies. In this case, different M2M access subscription identifiers are used over different access technologies.

## 5.6 IMSI vs. MIN

MIN (aka MIN-based IMSI) is almost universal in cdma2000 1x systems and true IMSI[15] is rarely used. On the other hand MIN is a much smaller resource and requires centralized administration. IMSI is a much larger resource and can be allocated independently by each nation. It is likely that early cdma2000 1x M2M devices will mainly be provisioned with MIN but they should support true IMSI to allow reprogramming some time in the future.

Support for MIN and MIN-based IMSI is necessary because most cdma2000 1x infrastructure today only supports MIN. Support for IMSI is important for M2M devices because the number of devices may eventually cause a migration towards true IMSI. Therefore:

**See SR-S-1x-01.**

**See SR-S-1x-02.**

**SR-S-1x-03: M2M devices that require a 1x Subscription Identifier shall support provisioning with MIN and MIN-based IMSI.**

## 5.7 Allocation Efficiency

For a given identifier type, the allocation efficiency is the number of allocated identifiers divided by the total number of identifiers that it is possible to allocate. The efficiency of allocation of MIN and IMSI are both important if a large number of M2M devices are added to the network but 3GPP2 has no direct control over the administering organizations. MIN is more likely to be tied to a landline numbering plan and therefore less efficiently utilized.

MIN administration is globally managed by both IFAST (outside North America[11]) and the MBI Administrator (within North America[10]). Given that 3GPP2 has an interest in efficient MIN administration to ensure the resource lasts as long as possible:

> **NOTE: 3GPP2 TSG-S has been requested to inform both IFAST and the MBI Administrator to notify it of any proposals to change administration guidelines or practices.**

IMSI administration is national so it would not be practical for 3GPP2 to monitor all national policies and practices. However, 3GPP2 should request that its regional partners and operators report any change in their national IMSI administration guidelines or practices:

> **NOTE: 3GPP2 members and partners have been notified of the importance of efficient IMSI allocation and requested to notify 3GPP2 TSG-S of any new or changed IMSI guidelines or practices.**

## 5.8 Protocol Limitations

The cdma2000 air interface does not distinguish between the transmission of a MIN-based IMSI or true IMSI from an MS. The ANSI-41 protocol assumes that the serving system knows whether an IMSI received from an MS is MIN-based or true as the Serving System has to place a true IMSI in the IMSI protocol field (otherwise the full IMSI cannot be transmitted) and has to place a MIN-based IMSI in the MIN protocol field if the home system does not support the IMSI protocol field (otherwise the message will be rejected due to a missing mandatory parameter).

The disconnect between the cdma2000 air interface and ANSI-41 can be resolved through the use of a database which identifies which roaming partners support true IMSI. If the RAN requests that IMSI be transmitted it can then be determined whether the response is MIN-based or true-IMSI based on the identification of the assignee of the IMSI block. However, it may not be optimal to maintain this database which requires global coordination between all operators.

**NOTES:**

- **TSG-C has been requested to investigate the practicality and benefits of adding an indicator to the protocol to distinguish between the transmission of a MIN-based and true-IMSI.**
- **TSG-X has been requested to investigate the practicality and benefits of the Serving system determining whether any given Home system supports true IMSI or not or allowing the inclusion of both a MIN and IMSI protocol field in ANSI-41 (so the home system can choose which field to use).**
- **TSG-X has been requested to investigate whether a database to store the IMSI-capabilities of roaming partner systems would have any standards impact.**

# 6 Problem Definitions and Proposed Solutions - Packet Data Access Subscription Identifiers

This section identifies problems with and potential solutions for applying current cdma2000 Packet Data access subscription identifiers for use in M2M numbering applications.

The Access Subscription Identifier used for cdma2000 Packet Data M2M services can be constructed in the form of user@realm as defined in IETF RFC 4282 NAI (Network Access Identifier) even if the full NAI is never transmitted or stored as a single unit.[3]

X.S0011 defines NAI as the, “user@domain construct which identifies the user and home network of the MS.“, and limits its length to 72 octets.

## 6.1 Size of M2M Packet Data Access Subscription Identifier

The full access subscription identifier, including both username and realm of an M2M device, may need to be carried in an NAI protocol field.

RFC 4282 requires that devices handling NAIs **must** support an NAI length of at least 72 octets. Support for an NAI length of 253 octets is **recommended**. X.S0011 limits the size of the NAI to "72 octets max". The RADIUS protocol is the most restrictive and only guarantees that 63 octets can be handled.[20]

Depending on how the NAI is used, the X.S0011 restriction on the length of the NAI may be problematic especially if the NAI carries the identity of the M2M access subscription identifier which includes the realm of the home operator and one or more routing realms.

In order to keep backwards compatibility with existing RADIUS based cdma2000 deployments it is highly desirable to maintain the RADIUS limitation on the username attribute size of 63 octets.

### 6.2 Size of NAI with Decoration

Given the assumption that the size of the home realm will not be significantly larger for M2M usages as compared to H2H (human to human) usages, there is another factor that will impact the size of the NAI, and that is decoration:

Routing Realm decorations are used to route AAA messages through parties such as visiting networks and roaming exchanges. Other decoration may be added to the NAI to convey additional information about the identity of the NAI or "modes" of operation, such as normal operation vs. emergency operations and perhaps affiliation to groups of M2M devices.

The use of decoration is an operator issue and they will need to ensure that, even with maximum decoration, an NAI stays within the recommended length limit.

### 6.3 Uniqueness of M2M Access Subscription Identifier

A packet data access subscription identifier is used in the access authentication of M2M devices and thus needs to be unique within the scope where authentication is performed. The packet data M2M access subscription identifier may also be required to be unique to other entities external to the party performing the authentication. This requirement can be met when using the M2M access subscription identifier in the form of NAI using the recommendation of IETF RFC 4282[3] where the NAI is composed of a username that is unique within a particular operator's network and a "realm" that is allocated as a Fully Qualified Domain Name (FQDN).

If allocation of M2M access subscription identifiers for packet data follows the normal rules for NAI as mentioned above, it will be globally unique. Note that some protocols may not require the entire NAI to be transmitted under all circumstances and in some protocols a non-unique identifier may be transmitted in order to transmit the unique identifier in a more protected (i.e., encrypted) protocol layer.

### 6.4 M2M Access Subscription Identifier Privacy

The access subscription identifier of the M2M device may be required to be kept private both over the air and between elements in the RAN and in the core network. M2M access subscription identifier privacy can be achieved via one of the following mechanisms:

1. Encryption: Encryption mechanisms do not impose any new restrictions on numbering of the M2M access subscription identifier that uses NAI format; thus no further investigation is needed.

2. Temporary Identifiers: Allocation of temporary identifiers is vendor/carrier specific. Such temporary identifiers are allocated for a short period of time and require uniqueness within a limited scope. A temporary identifier with a minimum length of 64 bits is believed to be enough to ensure uniqueness of M2M devices in a specific location.

3. Username Privacy: When the M2M access subscription identifier is formatted as an NAI, which contains the subscription identity, RFC 4282 provides for User Privacy by allowing the username portion of the NAI to be omitted and retaining the home realm and optionally routing decoration portions of the NAI. In this case, since the username is not included, numbering size restrictions associated with the subscription identifier specifically are not expected to impact the protocols. Sizing issues associated with the routing decoration and home realm remain relevant.

## 7 Problem Definitions and Proposed Solutions - Hardware Identifiers

This section identifies problems with and potential solutions for applying current 1x hardware identifiers for use in M2M numbering applications.

In this section, **SR-H-xx** refers to a Suggested Requirement that should be considered when developing hardware identifier requirements for cdma2000 development activities.

## 7.1 ESN Exhaustion

Both the IMEI and MEID are acceptable identifiers for M2M devices because these identifiers have sufficient numbers to accommodate M2M and regular devices, are globally administered, and no exhaustion issues are anticipated. The ESN is not recommended for use due to its near-exhaustion and the inability to apply for more codes (since June 30, 2010).[16] However, some manufacturers may still have enough stock to use for some models.

**SR-H-01: It is recommended that the ESN not be used as an M2M hardware identifier. However, the ESN may be used as an M2M hardware identifier when the ESN numbering resources are already available and where device production allows its use (e.g., end-of-life legacy type implementations). The MEID is the successor numbering identifier for ESN.**

## 7.2 Identifier Global Uniqueness

Every M2M device manufactured shall have a unique hardware identifier (i.e., one that is not allocated to any other device). 3GPP2 should develop mechanisms to ensure that a hardware identifier used for an M2M device cannot easily be used in another device.

**SR-H-02: Every M2M device shall have a globally unique hardware identifier.**

**NOTE: 3GPP2 TSGs have been requested to investigate methods to prevent duplication ('cloning') of a hardware identifier.**

## 7.3 Multi-Radio Access Technology (RAT) Hardware Identification

The decimal IMEI[9] is needed for multi-RAT modules (at least one cdma2000 mode and at least one 3GPP mode). Since the decimal IMEI can be used as an MEID, to satisfy SR-H-04 and to simplify M2M modules, it is recommended that multi-RAT M2M Communications Modules use a decimal IMEI as hardware identifier.[5] Single-RAT (cdma2000 mode only) modules should use a hexadecimal MEID.[6] This consideration does not apply to other radio technologies (e.g., WiFi, Bluetooth) that do not use the MEID or IMEI for hardware identification.

**SR-H-03: M2M Communications Modules with both 3GPP[2] and cdma2000 operational modes should be assigned only an IMEI/MEID (from RR=00 through RR=99) and use that identifier in cdma2000 modes as the MEID. Alternatively, it is acceptable for a module to have a separate MEID or an ESN for use in cdma2000 modes.**

**SR-H-04: M2M Communications Modules with only a cdma2000 operational mode should be assigned only an MEID from range RR=0xA0 and above. Alternatively, it is acceptable for a module to be assigned an ESN.**

### 7.4 Allocation Efficiency

Although both IMEI and particularly MEID are large identifiers that should be able to supply unique numbers for many years, M2M applications will increase the rate of depletion. 3GPP2 should continue to monitor the allocation practices for these identifiers and the assignment guidelines being used to ensure that allocations are as efficient as possible as requirements change in the future.

**NOTE: 3GPP2 TSG-S has been requested to continue to monitor IMEI assignment practices and guidelines by GSMA as the IMEI Administrator (i.e., BABT, TAF, MSAI, CTIA, including TIA multi-mode assignments).**

**NOTE: 3GPP2 TSG-S has been requested to continue to monitor MEID assignment practices and guidelines by the MEID Administrator (i.e., TIA).**

## 8 Problem Definitions and Proposed Solutions - IP Identifiers

This section identifies problems with and potential solutions for applying current Internet Protocol (IP) identifiers for use in M2M numbering applications.

In this section, **SR-IP-xx** refers to a Suggested Requirement that should be considered when developing IP identifier requirements for cdma2000 development activities.

[2] Assumptions for 3GPP are subject to change as their M2M specifications evolve.

## 8.1 IPv4 Exhaustion

3GPP2 X.S0011 defines the allocation and usage of IPv4 addresses[18] and IPv6 addresses[17] to each MS/AT. The IPv4 address consists of a 32-bit address-space and the IPv6 address consists of 128-bit address-space. Based on the input received by 3GPP2 from ARIN (American Registry for Internet Numbers)[21], the future availability of public IPv4 addresses is an industry wide concern. Deployment of a large number of M2M devices using IPv4 address will worsen the IPv4 address exhaustion issue.

There are several factors that affect the use of IPv6 as a solution for IPv4 exhaustion. Some of these factors include:

- Terminal IP capability,
- Type of application (IPv4 only, dual-stack capable, IPv6 only),
- Home network IP capability for IPv6,
- Roaming network IP capability for IPv6, and
- Internet capability for IPv6.

Potential solution options include the following:

- Use of IPv6 address for M2M devices: Usage of IPv6 addresses would definitely provide a sufficient number of IP addresses for M2M devices. The IPv6 address may be used with Simple IPv6 (as of P.S0011-B) and with Mobile IPv6 (MIP6) (as of X.S0011-D). PMIP operation for supporting IPv6 addresses was added in X.S0061.
- Use of private IPv4 address: The use of private IPv4 addresses in conjunction with NAT will also alleviate the IPv4 exhaustion issue. However, this option comes with a few limitations. For example, total active connections to the Internet will be limited by the number of public IP addresses multiplied by the number of ports available. In addition, support of Network-Initiated push service, when private IPv4 address is used, needs additional study by appropriate working groups.

**SR-IP-01: M2M devices should support IPv6 addressing.**

**SR-IP-02: In addition to IPv6 addressing, M2M devices may also support IPv4 addressing.**

# 9 Problem Definitions and Proposed Solutions - Mobile Directory Numbers

This section identifies problems with and potential solutions for applying current cdma2000 Mobile Directory Numbers (MDNs) for use in M2M numbering applications.

The MDN or Phone Number, conforming to ITU-T E.164[13], is required for user text-messaging, for terminating calls to a mobile device, for originating calls with calling party identification and for some other circuit-related functions. The use of MDN by M2M devices is an important issue given that telephone numbering plans are difficult to change and some, such as the North American fixed 10-digit plan, have relatively little room to grow. This section considers whether the use of the MDN in M2M networks can be avoided.

In this section, **SR-MDN-xx** refers to a Suggested Requirement that should be considered when developing MDN requirements for cdma2000 development activities.

## 9.1 Use of Phone Numbers for PSTN Calls

It is assumed that the majority of M2M devices will not need the ability to make circuit-switched calls. This is because M2M applications are, by definition, between two machines, therefore the use of voice or TDD (Telephone Devices for the Deaf) is unlikely. The use of modem tones over a circuit-switched path to transmit data is inefficient (when possible) in wireless systems and becoming increasingly rare even in fixed telecommunications systems. Therefore M2M devices can be assumed to not require an MDN for the purposes of connecting voice or analog modem data calls.

If M2M devices in cdma2000 networks make circuit-switched, TDD, or analog modem calls and therefore need an MDN for this purpose, existing telephony numbering plan capacity could be stretched or exhausted.

> **SR-MDN-01: For any M2M devices in** cdma2000 **networks that use voice, TDD or analog modem calls operators should ensure sufficient MDN resources are available.**

## 9.2 Use of Phone Numbers for cdma2000 SMS

Some systems may require phone numbers to identify non-voice-band services such as SMS.

ANSI-41-based SMS was originally designed to work with MIN, not MDN. It was only after TIA IS-841 was published in September, 2000 that ANSI-41 systems gained the ability to route SMS using MDN instead of MIN. Since then, however, some Message Centers and other core network entities may have been designed to work only with MDN and not with MIN.

There does not appear to be a problem for cdma2000 SMS as the protocols have been designed such that an operator could send/receive SMS from an M2M device without having to allocate an MDN.

**SR-MDN-02: MIN or IMSI addressing should be considered for M2M SMS if operators do not have sufficient MDN resources available.**

### 9.3 MDNs for Cross-Technology SMS

3GPP technologies (e.g., GSM) may require an MDN (MSISDN) for SMS and avoiding this may not currently be possible. Therefore, SMS directly between a cdma2000 device and a 3GPP device might require an MDN to be allocated. Alternatively, if there is an M2M server mediating the devices direct SMS might not be required and the MDN might be required only for the 3GPP device.

**SR-MDN-03: M2M applications should avoid the use of MDN to the greatest extent possible for inter-technology SMS. One possible solution is to use a mediation device that splits the SMS transaction into a cdma2000-network part and a 3GPP-network part.**

### 9.4 MDNs for Other Services

At this time, no other cdma2000 services (beyond voice and SMS) have been identified that require an MDN.

### 9.5 VoIP and MDN

It is not anticipated that VoIP calls will be common with M2M devices, however given that the applications of M2M are not fully defined, it is possible. If VoIP is used, an MDN will be required if the M2M device's VoIP calls can interconnect with the PSTN, i.e., receive VoIP calls or initiate VoIP calls with calling number identification.

The best advice is to try to find alternatives to any M2M services that would use VoIP in a way that requires an MDN.

**SR-MDN-04: If a cdma2000 operator anticipates a large number of M2M devices subscribing to their service that will use VoIP calls in such a way that an MDN will be required, alternative forms of communication that do not require an MDN should be investigated.**

### 9.6 No Premature Exhaustion of MDNs from M2M

It seems unlikely that there will be phone number exhaustion problems from a large number of cdma2000 capable mobiles with M2M applications. A problem will exist only if a large amount of direct cdma2000-to-3GPP or 3GPP-to-cdma2000 device-to-device (unmediated) SMS is expected or other services using phone numbers are unexpectedly required by a large number of M2M devices.

## 10 PROBLEM DEFINITIONS AND PROPOSED SOLUTIONS - CARD IDENTIFIERS

This section identifies problems with and potential solutions for applying current cdma2000 card identifiers for use in M2M numbering applications.

In this section, **SR-CID-xx** refers to a Suggested Requirement that should be considered when developing cdma2000 card identifier requirements for cdma2000 development activities.

The original generation of cdma2000 smart cards was the R-UIM developed around 2000 in the C.S0023 family of specifications and the second generation is the CSIM, defined in C.S0065. Smart cards are identified during call processing via the stored MIN or IMSI subscription identifier which has the same requirements as these identifiers when stored in an integrated phone. Smart cards also included a hardware identifier (permanent for the life of the device), the UIMID, which was used to replace the ESN in some protocol messages and therefore had the same format and allocation system. Just as ESN has been migrated to and replaced by MEID due to ESN resource exhaustion the UIMID is also being replaced by either of two forms of EUIMID, the SF_EUIMID based on MEID (and assigned from the same numbering space) or the LF_EUIMID based on the ICCID[14] already in all smart cards (including older designs such as the GSM SIM). As with MEID, the EUIMID has a pseudo-identifier, the 32-bit pUIMID to provide backwards compatibility.

The importance of the Card ID (as opposed to the subscription identifier) is for several reasons:

- Cards are often manufactured without a MIN or IMSI being provisioned to allow activation in any of the operator's regions.
- They are unchanging and may be useful for lawful intercept purposes.
- They identify the manufacturer of a card.
- They can be useful for stock control and inventory.
- The capabilities of the card (e.g. memory size) can be determined without querying the card.
- Useful statistics for network management and marketing purposes can be broken down by card manufacturer or card type.

It is not necessary to discuss the card subscription identifiers further in this section as the same problems and solutions apply as to subscription identifiers in integrated devices.

## 10.1 UIMID Exhaustion for M2M

The UIMID resource is essentially exhausted and the administrator, TIA, has not accepted applications for new assignments since June 30, 2010.[8]

**SR-CID-01: Cards designed for M2M devices should not use the UIMID. The SF_EUIMID (hexadecimal MEID) and LF_EUIMID (ICCID) are the successor identifiers.**

## 10.2 EUIMID for M2M

Both the SF_EUIMID and LF_EUIMID are significantly larger numbering spaces than UIMID and will last for many years even with billions of identifiers being allocated each year.

The SF_EUIMID is allocated by the TIA Administrator from the MEID hexadecimal space meaning that the first digit must be "A".."F" but the remaining 13 digits can be "0"…"9" or "A"…"F" (the full hexadecimal range). This means that the TIA has 6E13 numbers to allocate. If one billion were allocated each year the resource would last 60,000 years and, in that time, other portions of the numbering space could be opened up with the agreement of other organizations to avoid the all-decimal IMEI numbering space.

The LF_EUIMID is the ICCID already found in most smart cards. This is an 18 digit number (not counting the Luhn check digit) defined in ITU-T Recommendation E.118. The first two digits are always "89" and the next 5 digits include the 1-3 digit country code and the "Issuer Identifier Number". This leaves 11 digits for each issuer, a total of 100 billion numbers.

While this ICCID allows for many numbers per issuer the number of issuers is constrained, particularly in the majority of countries that have 3 digit landline country codes. A 3-digit country code only allows 100 issuers to be defined. If every card vendor was a separate issuer the resource in each country could quickly be exhausted. To avoid exhaustion of issuer codes it is recommended that the cellular operator is the issuer and that they manage the 11 digit "Individual Account Identification Number" portion, allocating ranges of numbers to card manufacturers as needed.

**SR-CID-02: If cards are identified with LF_EUIMID/ICCID the cellular operator should be the card issuer for numbering purposes and should allocate portions of the Individual Account Identification Number as needed.**

**SR-CID-03: The ICCID Individual Account Identification Number shall be allocated by the issuer in ranges matching the number of cards manufactured.**

## 10.3 Card ID Uniqueness

If the SF_EUIMID is chosen as the Card ID, it is important that the MEID hexadecimal range of numbers is allocated by the appropriate administrator – TIA or an authorized administrator designated by TIA.[7] Note that the decimal range (IMEI) should not be used.

**SR-CID-04: SF_EUIMID codes should only be obtained from the TIA or an administrator authorized by the TIA.**

If the LF_EUIMID is chosen as the Card ID it is important that the numbers are allocated by the appropriate administrator – national or ITU-T and that the issuer keeps permanent records of assignments to ensure they are not accidentally reused.

**SR-CID-05: The country code used in LF_EUIMID/ICCID codes shall be that of the issuer.**

**SR-CID-06: The Issuer Identifier Number shall be allocated by the ITU-T or a national regulator coordinating with the ITU-T.**

**SR-CID-07: Ranges of Individual Account Identification Number allocated by the issuer shall be recorded permanently.**

# 11 Problem Definitions and Proposed Solutions - Radio Access Network (RAN) Identifiers

This section identifies problems with and potential solutions for applying current cdma2000 RAN identifiers for use in M2M numbering applications. This section also describes how the potential solutions could be harmonized with other organizations.

RAN is the radio access portion of the cdma2000 network and uses a variety of identifiers for the base stations and terminals in both cdma2000 1x and HRPD modes.

In this section, **SR-RAN-xx** refers to a Suggested Requirement that should be considered when developing cdma2000 RAN identifier requirements for cdma2000 development activities.

## 11.1 SID (System Identifier)

Every cdma2000 Base Station needs to broadcast a 15 bit SID code. A unique code should be assigned to an operator for use by a group of related and contiguous base stations. SID codes are assigned by a variety of organizations including national regulators and IFAST.[12]

## 11.2 SID Codes

15 bits provides 32k unique SID codes. Since 16 bits are used on the network there are another 32k that are available for use as so-called "BID" (Billing ID) codes. Given that many operators use only one SID code or a handful there does not appear to be a shortage. Furthermore, the number of SID codes is not directly related to the number of devices accessing a network, and only loosely related to the number of base stations.

## 11.3 SID Code Uniqueness

The distributed nature of SID assignments has created problems with maintaining uniqueness. One factor is lack of awareness by operators leading to self-assignment of codes and conflicts (many of which are document on the IFAST website, http://ifast.org). Another is lack of awareness by regulators leading to allocation of national SID codes within the wrong blocks (i.e. other than originally defined by TIA in TSB-29, now incorporated into the IFAST database). Finally, in the United States, the FCC established a method for assignment of SID codes but not management of the codes meaning that license ownership and name changes are generally not reflected in the available information. Furthermore, the FCC assigned cellular SID codes, CTIA and CIBERNET (now Mach) assigned PCS codes and no authority was given for 700 MHz, 1700 MHz assignments etc.

**SR-RAN-01: The likelihood of SID uniqueness should be maximized by an operator by allocating SID Codes from the appropriate authority (usually a national regulator, contracted third party or IFAST) and ensuring that changes (such as change of ownership of a licensed area identified by a SID) are promptly reported to the same organization.**

## 11.4 NID (Network Identification Number)

The NID is a 16 bit number that extends the SID in cdma2000 systems. The base stations within a single SID may share the same NID (e.g. “1”) or subgroups (even a single base station) may be assigned different NID codes.

## 11.5 NID Codes

Since there are 65,536 unique NID codes, they are managed separately by each operator and the number of NID codes required is not related to the number of devices there is no anticipated problem with the NID code.

## 11.6 NID Uniqueness

Since NID codes extend the SID code the SID+NID combination is unique to an operator as long as the SID is uniquely assigned to an operator.

**See SR-RAN-01.**

## 11.7 MCC+MNC

cdma2000 base stations can optionally broadcast an MCC (ITU-T E.212 Mobile Country Code) and MNC (ITU-T E.212 Mobile Network Code). This additional identifying information can also be globally unique to an operator (or wild-carded to all-1-bits) and can make PRLs more efficient for operators that have historically used many SID codes.

The MCC code is always 3 digits and assigned by the ITU. The MNC is assigned nationally and although theoretically it can be 1, 2 or 3 digits long, in practice it is always two digits long. cdma2000, in particular, only supports the transmission of 2 digit MNC codes (IMSI_11_12) from the base station towards a mobile.

## 11.8 MCC Codes

There are 1,000 codes and most countries have just been assigned one. There does not appear to be a shortage of these codes even if several more countries require additional MCC codes.

## 11.9 MCC Uniqueness

MCC codes are unique to a country as long as the ITU-assigned value is used.

## 11.10 MNC Codes

There are only 100 MNC codes per MCC. The USA, for example, with 7 MCCs, has 700 MNC codes. For most countries this is sufficient, and when not sufficient can be resolved by allocating a new MCC to that country. The number of MNCs needed reflects the number of operators and is not directly related to the number of devices. Therefore, M2M should not create a shortage of MNC codes

## 11.11 MNC Uniqueness

MNC codes are assigned by national regulators or other authorized administrators (e.g., Telecordia, authorized by ATIS IOC, in the United States). MNC codes will be unique to an operator when used in combination with an MCC as long as the administrator-assigned value is used.

## 11.12 HRPD Serving Area Identifier[1]

A group of HRPD base stations of an operator's network are identified by the "Subnet Identifier", defined for the purposes of this report as the 'left-hand' portion of a 128-bit Sector ID when masked by the Subnet Mask (a series of 1's followed by a series of 0's totaling 128 bits). The right-hand portion is the individual identifier of a user device or a base station within the network. Both the Sector ID and Subnet Mask are broadcast by the base station using overhead channel and can be used to calculate the Subnet Identifier.

The four globally unique Subnet Identifier formats follow:

- IPv6 address[17] prefixed by 48-bit Global Routing Prefix and 16-bit Subnet ID. The remaining 64 masked bits will be the Interface ID (64-bit 'MAC' address in EUI-64 format).[4]
- 1-63 '0' bits followed by '101' followed by a 12-bit (3 digit) MCC, followed by a 12-bit (3 digit) MNC. The remaining bits will be masked out.
- 1-63 '0' bits followed by '100' followed by 15-bit SID. The remaining bits will be masked out.
- 1-63 '0' bits followed by '110' followed by IPv4 Subnet Prefix. The remaining bits will be masked out.

## 11.13 Subnet ID Uniqueness

Uniqueness of the Subnet ID is important to ensure proper choice of HRPD network and proper data roaming. Any of the above four formats will ensure a globally unique identifier if the non-masked portions are allocated by the appropriate assignment authority. Other "Site-Local" formats will not necessarily be globally unique.

## 11.14 Subnet IDs

All three of the above formats only require sufficient codes to identify all serving regions in the world. The smallest resource is the identifier based on SID and since an operator only needs one SID code, an expanded number of devices for M2M purposes should not cause exhaustion of this resource, even if the number of operators increases significantly. If the number of SID codes did ever become a constraint the other two formats would provide more resources.

### 11.15 HRPD Sector ID

A sector can be uniquely identified by a "SectorID" which is 128 bits long, the same size as an IPv6 address. This will be globally unique if one of the four formats identified above are used as opposed to the "Locally Unique" formats.

The Sector ID format is also used for assigning the device identifier (UATI). Since the operator assigns this dynamically to each mobile the UATI will be globally unique if the Subnet Prefix is globally unique and the operator ensures that the remainder of the identifier is unique within the network identified by the Subnet Prefix.

## 12 Recommendations

The following suggested requirements for cdma2000 M2M 1x subscription identifiers have been included in this document for consideration when developing requirements for cdma2000 development activities:

- SR-S-1x-01: All cdma2000 M2M devices that require a 1x Subscription Identifier should support provisioning with true IMSI.
- SR-S-1x-02: M2M devices that may roam and that are provisioned with true IMSI should also be provisioned with MIN and MIN-based IMSI.
- SR-S-1x-03: M2M devices that require a 1x Subscription Identifier shall support provisioning with MIN and MIN-based IMSI.

The following suggested requirements for cdma2000 M2M hardware identifiers have been included in this document for consideration when developing requirements for cdma2000 development activities:

- SR-H-01: It is recommended that the ESN not be used as an M2M hardware identifier. However, the ESN may be used as an M2M hardware identifier when the ESN numbering resources are already available and where device production allows its use (e.g., end-of-life legacy type implementations). The MEID is the successor numbering identifier for ESN.
- SR-H-02: Every M2M device shall have a globally unique hardware identifier.

- SR-H-03: M2M Communications Modules with both 3GPP and cdma2000 operational modes should be assigned only an IMEI/MEID (from RR=00 through RR=99) and use that identifier in cdma2000 modes as the MEID. Alternatively, it is acceptable for a module to have a separate MEID or an ESN for use in cdma2000 modes.
- SR-H-04: M2M Communications Modules with only a cdma2000 operational mode should be assigned only an MEID from range RR=0xA0 and above. Alternatively, it is acceptable for a module to be assigned an ESN.

The following suggested requirements for cdma2000 M2M IP identifiers have been included in this document for consideration when developing requirements for cdma2000 development activities:

- SR-IP-01: M2M devices should support IPv6 addressing.
- SR-IP-02: In addition to IPv6 addressing, M2M devices may also support IPv4 addressing.

The following suggested requirements for MDN (Mobile Directory Numbers) have been included in this document for consideration when developing requirements for cdma2000 development activities:

- SR-MDN-01: For any M2M devices in cdma2000 networks that use voice, TDD or analog modem calls operators should ensure sufficient MDN resources are available.
- SR-MDN-02: MIN or IMSI addressing should be considered for M2M SMS if operators do not have sufficient MDN resources available.
- SR-MDN-03: M2M applications should avoid the use of MDN to the greatest extent possible for inter-technology SMS. One possible solution is to use a mediation device that splits the SMS transaction into a cdma2000-network part and a 3GPP-network part.
- SR-MDN-04: If a cdma2000 operator anticipates a large number of M2M devices subscribing to their service that will use VoIP calls in such a way that an MDN will be required, alternative forms of communication that do not require an MDN should be investigated. Failing this, operators should ensure sufficient MDN resources are available.

The following suggested requirements for cdma2000 Card identifiers have been included in this document for consideration when developing requirements for cdma2000 development activities:

- SR-CID-01: Cards designed for M2M devices should not use the UIMID. The SF_EUIMID (hexadecimal MEID) and LF_EUIMID (ICCID) are the successor identifiers.
- SR-CID-02: If cards are identified with LF_EUIMID/ICCID the cellular operator should be the card issuer for numbering purposes and should allocate portions of the Individual Account Identification Number as needed.
- SR-CID-03: The ICCID Individual Account Identification Number shall be allocated by the issuer in ranges matching the number of cards manufactured.
- SR-CID-04: SF_EUIMID codes should only be obtained from the TIA or an administrator authorized by the TIA.
- SR-CID-05: The country code used in LF_EUIMID/ICCID codes shall be that of the issuer.
- SR-CID-06: The Issuer Identifier Number shall be allocated by the ITU-T or a national regulator coordinating with the ITU-T.
- SR-CID-07: Ranges of Individual Account Identification Number allocated by the issuer shall be recorded permanently.

The following suggested requirements for cdma2000 RAN identifiers have been included in this document for consideration when developing requirements for cdma2000 development activities:

- SR-RAN-01: The likelihood of SID uniqueness should be maximized by an operator by allocating SID Codes from the appropriate authority (usually a national regulator, contracted third party or IFAST) and ensuring that changes (such as change of ownership of a licensed area identified by a SID) are promptly reported to the same organization.

# 13 Additional Notes

The following have been requested of other groups within 3GPP2 and should be considered to be on-going as of the date of this report.

- 3GPP2 TSG-S has been requested to inform both IFAST and the MBI Administrator to notify it of any proposals to change administration guidelines or practices.

- 3GPP2 members and partners have been notified of the importance of efficient IMSI allocation and requested to notify 3GPP2 TSG-S of any new or changed IMSI guidelines or practices.
- 3GPP2 TSGs have been requested to investigate methods to prevent duplication ('cloning') of a hardware identifier.
- 3GPP2 TSG-S has been requested to continue to monitor IMEI assignment practices and guidelines by GSMA as the IMEI Administrator (i.e., BABT, TAF, MSAI, CTIA, including TIA multi-mode assignments).
- 3GPP2 TSG-S has been requested to continue to monitor MEID assignment practices and guidelines by the MEID Administrator (i.e., TIA).