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THE CONCEPT OF UNIQUE IDENTITY

The Internet of Things embodies the means by which one thing can communicate with another thing via the Internet. Here a thing is an "entity" as shown in the graphic below where an object communicates to another object or a person, legal or real. For that "entity" to communicate it must possess an identifier.

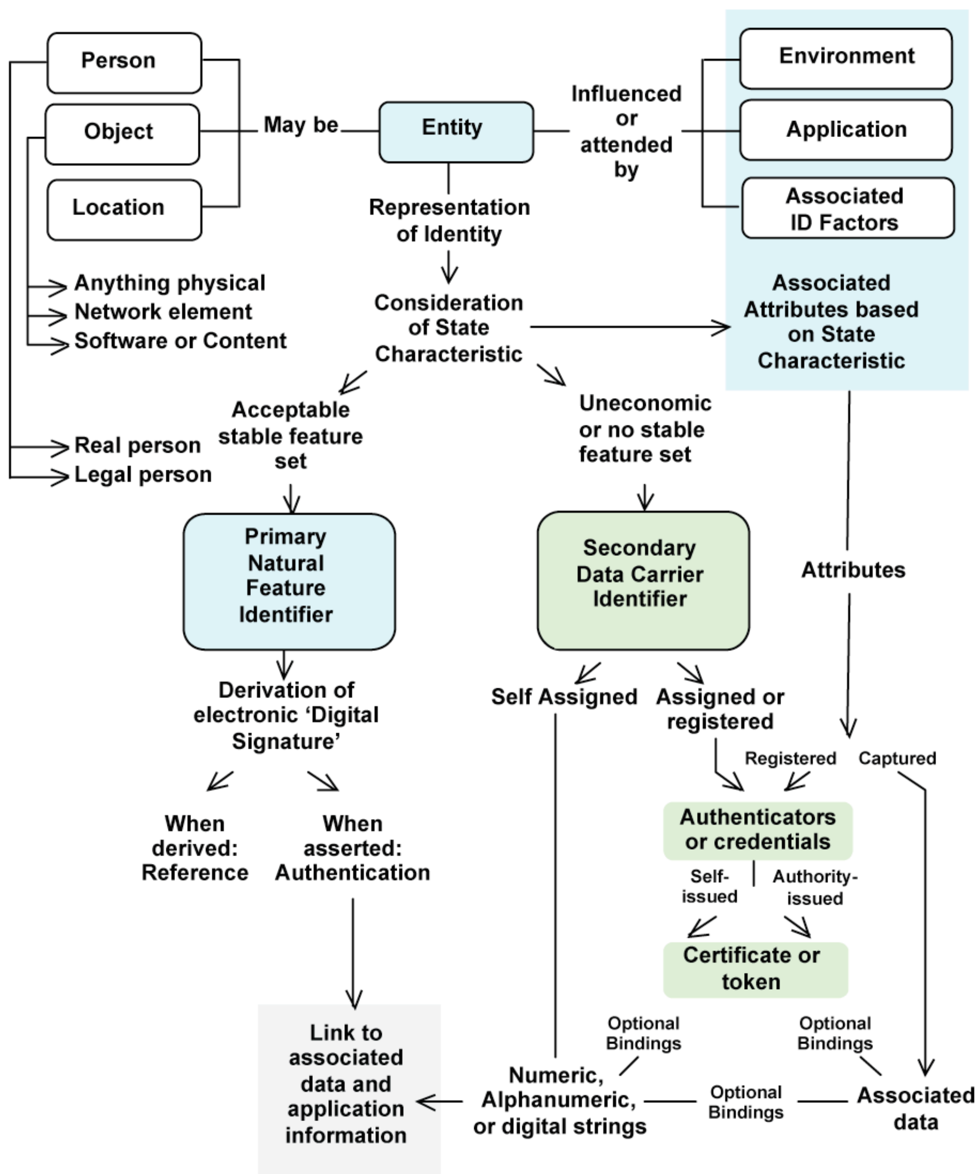

Figure 1 — Ontology of identity

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A telephone number is a good example of an identifier of an object on a network. Internationally[1], the telephone number is comprised of several parts.

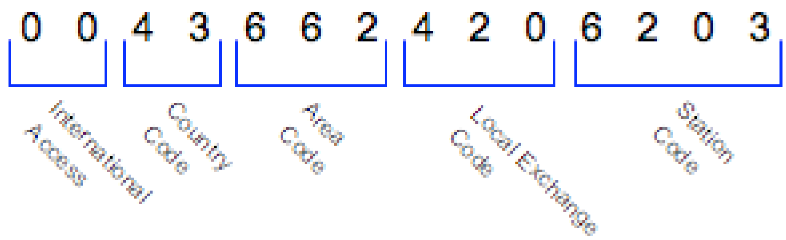

Figure 2 — ITU telephone network numbering plan

Another example of an identifier of an object on a network is an I.P. address. Using IPv4 the 32-bit address of 192.168.0.6 can be illustrated as shown in Figure 3.

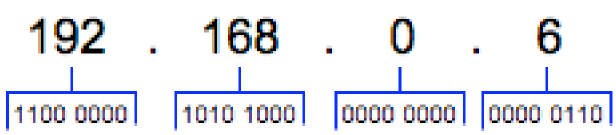

Figure 3 — Internet Protocol (I.P.) address using IPv4

In both of the above Figures (2 and 3), users of the network have agreed upon a common numbering system. This common agreement permits each station on the telephone network or each device on the Internet to be able to communicate with any other device on these common networks.

The Internet of Things has no such universal numbering.

[1] The "00" international access was established by the International Telecommunications Union (ITU). There is also a North American Numbering Plan (NANP) where "011" is used for international access. The NANP is implemented by Anguilla, Antigua and Barbuda, Bahamas, Barbados, Bermuda, British Virgin Islands, Canada, Cayman Islands, Dominica, Dominican Republic, Grenada, Jamaica, Montserrat, Saint Kitts and Nevis, Saint Lucia, Saint Vincent and the Grenadines, Trinidad and Tobago, Turks and Caicos Islands, United States, including Guam, Northern Mariana Islands, Puerto Rico, U.S. Virgin Islands, and American Samoa.

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Extant Numbering Systems for RFID

There are several existing systems to uniquely identify physical objects in an RFID context. These include:

- ISO/IEC 15459-1:2006, *Information technology — Unique identifiers — Part 1: Unique identifiers for transport units*
- ISO/IEC 15459-2:2006, *Information technology — Unique identifiers — Part 2: Registration procedures*
- ISO/IEC 15459-3:2006, *Information technology — Unique identifiers — Part 3: Common rules for unique identifiers*
- ISO/IEC 15459-4:2006, *Information technology — Unique identifiers — Part 4: Unique identifiers for individual items*
- ISO/IEC 15459-5:2007, *Information technology — Unique identifiers — Part 5: Unique identifier for returnable transport items (RTIs)*
- ISO/IEC 15459-6:2007, *Information technology — Unique identifiers — Part 6: Unique identifier for product groupings*
- ISO/IEC CD15459-7, *Information technology — Unique identifiers — Part 7: Product packaging*
- ISO/IEC 15963:2004, *Information technology — Radio frequency identification for item management — Unique identification for RF tags*
- ISO/IEC 7816-5:2004, *Identification cards — Integrated circuit cards — Part 5: Registration of application providers,*
- ISO/IEC 7816-6:2004, *Identification cards — Integrated circuit cards — Part 6: Inter-industry data elements for interchange*
- *EPCglobal Tag Data Standards, Version 1.5*

Figure 4 shows the memory layout of ISO/IEC 18000-6, Type C and ISO/IEC 18000-3, Mode 3 RF tags. UIIs are encoded in Memory Bank ‘01’ as shown in Figure 5. The 15459 series deals specifically with Unique Item Identifiers (UIIs), including the means to identify physical objects according to ISO TC 122’s 1736x series and EPC.

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ISO/IEC 18000-6C and -3m3 and EPCglobal Memory Architecture

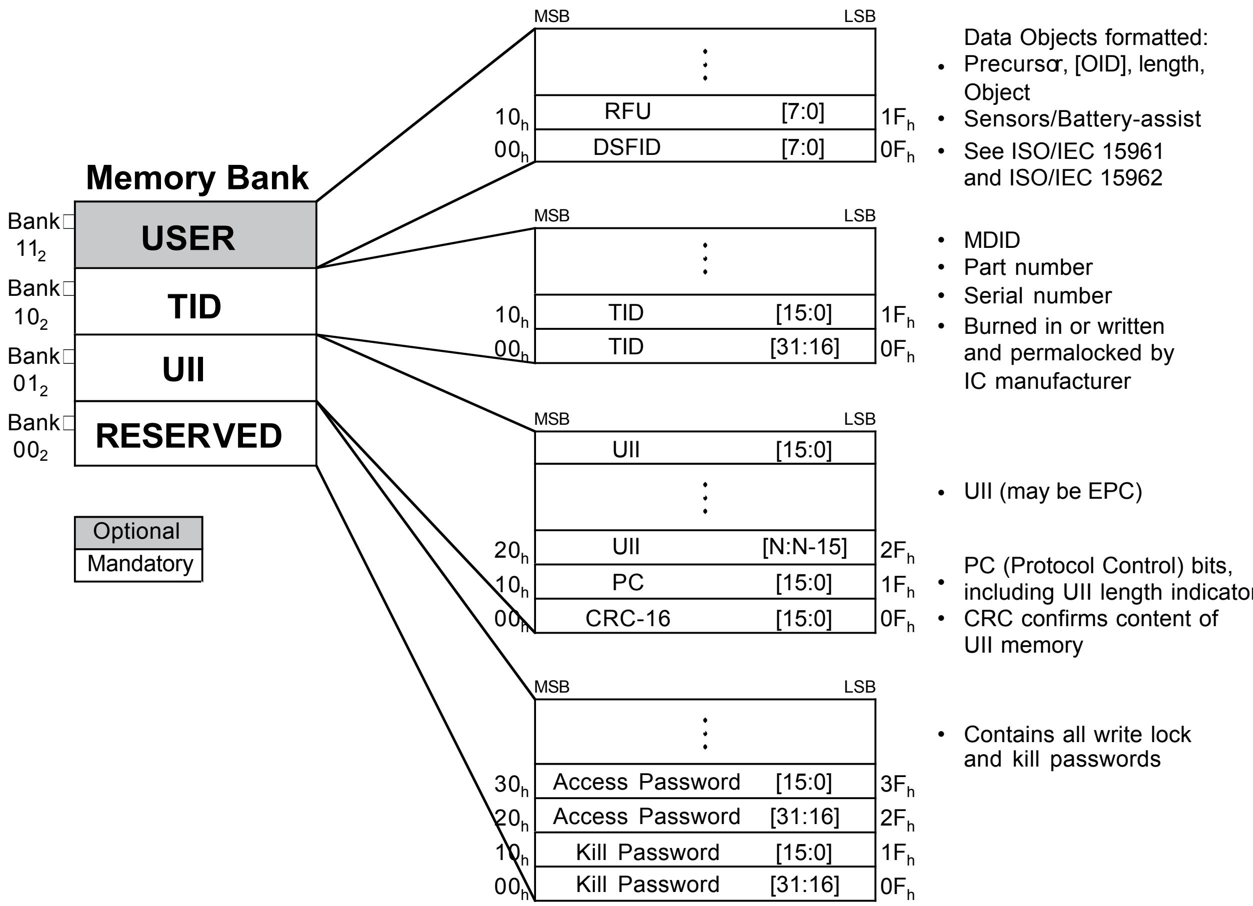

Figure 4 — 18000-6C & 3m3, Memory structure

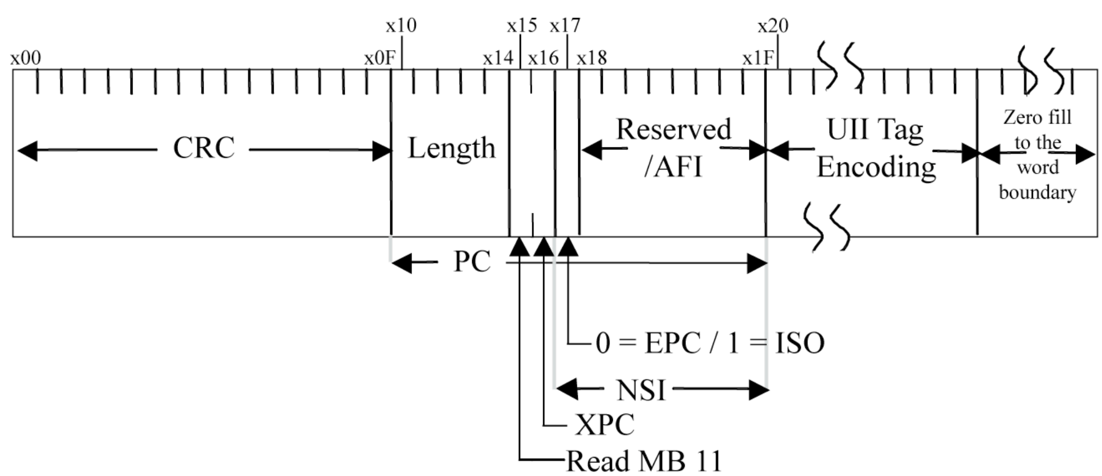

Figure 5 — 18000-6C & 3m3, Memory Bank (MB) "01_2"

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Unique Identifier of a Physical Object (UII)

The UII can follow one of two formats, designated by the state of Bit 17h of Memory Bank “01_2”. If Bit 17 is a “1” what follows at Bit 18h is an AFI (Application Family Identifier). The AFI formats are shared between JTC 1/SC 31 and JTC 1/SC 17 (Integrated Circuit Cards) and their values are as shown in Table 1. The values under the control of JTC 1/SC 31 are shown in Table 2.

Table 1 – AFI values

AFI most significant nibble	AFI least significant nibble	Meaning	Examples / note
0	0	All families and subfamilies	No applicative pre-selection
X	0	All families and subfamilies	No applicative pre-selection
X	Y	Only the Yth subfamily of family X	
1	0, Y	Transport	Mass transit, Bus, Airline
2	0, Y	Financial	IEP, Banking, Retail
3	0, Y	Identification	Access control
4	0, Y	Telecommunication	Public telephony
5	0, Y	Medical	
6	0, Y	Multimedia	Internet services
7	0, Y	Gaming	
8	0, Y	Data storage	Portable files
9	0, Y	GS1 system for Application Identifiers	Managed by JTC 1/SC 31
A	0, Y	ISO/IEC JTC 1SC 31	Data Identifiers as defined in ISO/IEC 15418
B	0, Y	UPU	Managed by JTC 1/SC 31
C	0, Y	IATA	Managed by JTC 1
D	0, Y	RFU	Managed by JTC 1/SC 17
E	0, Y	RFU	Managed by JTC 1/SC 17
F	0, Y	RFU	Managed by JTC 1/SC 17

Table 2 – AFI values assigned by JTC 1/SC 31

Organization: function	AFI byte	Data Format binary	OID for UII	Data Format for additional memory	Root-OID for other data
ISO/IEC 17367: *Supply chain applications of RFID – Product tagging* [separate UII memory, with Data Identifiers in separate memory]	A1	xxx01010 (means DI)	1 0 15459 4	xxx01010 (means DI)	1 0 15418 1 (“1” suffix is to identify DIs, “0” for AIs)
ISO/IEC 17365: *Supply chain applications of RFID – Transport unit* [separate UII memory, with Data Identifiers in separate memory]	A2	xxx01010	1 0 15459 1	xxx01010	1 0 15418 1
ISO/IEC 17364: *Supply chain applications of RFID – Returnable transport item* [separate UII memory, with Data Identifiers in separate memory]	A3	xxx01010	1 0 15459 5	xxx01010	1 0 15418 1
ISO/IEC 17367: *Supply chain applications of RFID – Product tagging*, containing hazardous materials [separate UII memory,	A4	xxx01010	1 0 15459 4	xxx01010	1 0 15418 1

Organization: function	AFI byte	Data Format binary	OID for UII	Data Format for additional memory	Root-OID for other data
with Data Identifiers in separate memory]					
ISO/IEC 17366: *Supply chain applications of RFID – Product packaging* [separate UII memory, with Data Identifiers in separate memory]	A5	xxx01010	1 0 15459 4	xxx01010	1 0 15418 1
ISO/IEC 17366: *Supply chain applications of RFID – Product packaging*, containing hazardous materials [separate UII memory, with Data Identifiers in separate memory]	A6	xxx01010	1 0 15459 4	xxx01010	1 0 15418 1
ISO/IEC 17365: *Supply chain applications of RFID – Transport unit, containing hazardous materials* [separate UII memory, with Data Identifiers in separate memory]	A7	xxx01010	1 0 15459 1	xxx01010	1 0 15418 1
ISO/IEC 17364: *Supply chain applications of RFID – Returnable transport item*, containing hazardous materials [separate UII memory, with Data Identifiers in separate memory]	A8	xxx01010	1 0 15459 5	xxx01010	1 0 15418 1
ISO/IEC 17363: *Supply chain applications of RFID – Freight containers* [separate UII memory, with Data Identifiers in separate memory]	A9	xxx01101	1 0 10891 0	xxx01010	1 0 15418 1
ISO/IEC 17363: *Supply chain applications of RFID – Freight containers*, containing hazardous materials [separate UII memory, with Data Identifiers in separate memory]	AA	xxx01101	1 0 10891 0	xxx01010	1 0 15418 1
IATA: baggage handling [separate UII memory]	C1	xxx01100	1 0 15961 12 1	xxx01100	1 0 15961 12
EDItEUR: library items	C2	xxx00110	1 0 15961 8 1		1 0 15961 8
ISBT item level blood products [7]	C3				

If Bit 17h is a “0” what follows, beginning at Bit 20h is an EPC format. Table 3 shows an illustrative example of an EPC, specifically a Serialized GTIN.

Table 3 – EPC UII

	Header	Filter Value	Partition	Company Prefix	Item Reference	Serial Number
SGTIN-96	8 bits	3 bits	3 bits	20-40 bits	24-4 bits	38 bits
	0011 0000	TDS Tbl 5	TDS Tbl 6			

The EPC UII can take many different forms including the identity of a physical object for sale (SGTIN), a shipping container (SSCC), a returnable transport item (GRAI), an asset identifier (GIAI), a serialized location code (SGLN), a serialized service code (GSRN), or a serialized document number (GDTI). Further there are permutations of these types of identification, which has been assigned a unique header. These headers begin at Bit 20h of Memory Bank “01” (Figures 4 and 5). A listing of these headers, as of 1 March 2008 can be found in Table 4.

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Table 4 – EPC Headers

Header Value (binary)	Header Value (hex)	Encoding Length (Bits)	Encoding scheme
0000 0000	00	NA	Unprogrammed tag
0000 0001	01	NA	Reserved for future use
0000 001x	02, 03	NA	Reserved for future use
0000 01xx	04, 05 06, 07	NA	Reserved for future use
0000 1000 to 0000 1111	08 to 0F	NA	Available after 2009-07-01
0001 0000 to 0010 1011	10 to 2B	NA	Reserved for future use
0010 1100	2C	96	GDTI-96
0010 1101	2D	96	GSRN-96
0010 1110	2E	96	Reserved for future use
0010 1111	2F	96	DoD-96
0011 0000	30	96	SGTIN-96
0011 0001	31	96	SSCC-96
0011 0010	32	96	SGLN-96
0011 0011	33	96	GRAI-96
0011 0100	34	96	GIAI-96
0011 0101	35	96	GID-96
0011 0110	36	198	SGTIN-198
0011 0111	37	170	GRAI-170
0011 1000	38	202	GIAI-202
0011 1001	39	195	SGLN-195
0011 1010	3A	113	GDTI-113
0011 1011 to 0011 1111	3B to 3F	NA	Reserved for future use
0100 0000 to 0111 1111	40 to 7F	NA	Available after 2009-07-01
1000 0000 to 1011 1111	80 to BF	NA	Available after 2009-07-01
1100 0000 to 1100 1101	C0 to CD	NA	Available after 2009-07-01
1100 1110	CE	NA	Available after 2009-07-01
1100 1111 to 1111 1110	CF to FE	NA	Available after 2009-07-01
1111 1111	FF	NA	Reserved for future headers longer than 8 bits

As can be seen above, of the 256 possible values available with an 8-bit code, EPCglobal has used 14 of these codes.

Unique Tag Identification (TID)

ISO/IEC 15963 is the overarching standard to uniquely identify an RF tag (TID), as opposed to the physical object to which it is attached. An "allocation class" is an 8-bit value used to classify organizations allowed to allocate unique tag identification. A unique TID consists of three fields, as shown in Table 5.

Table 5 — Structure of the permanent unique TID

AC	TID issuer registration number	Serial number
8 bits	Size defined by AC value	Size defined by AC and TID issuer value

MSB LSB

The registration authorities identified in Table 6 assign the length of the RF tag unique identifier.

Table 6 — Classes of TID issuer

Allocation class value	Class	TID issuer identifier size	Serial number size	Registration authority (of TID issuer registration number)
000xxxxx	INCITS 256	per ANS INCITS 256	per ANS INCITS 256	autoid.org
001x xxxx to 1101 xxxx	RFU	N/A	N/A	Reserved for future use by ISO
'11100000'	ISO/IEC 7816-6	8 bits	48 bits	APACS (ISO/IEC 7816-6 registration authority)
'11100001'	ISO/TS 14816	per NEN	per NEN	NEN (ISO/TS 14816 registration authority)
'11100010'	GS1	per GS1	per GS1	GS1
1110 0011 to 1111 1111	RFU	N/A	N/A	Reserved for future use by ISO

Table 7 provides a listing of selected ISO/IEC 15963 Allocation Classes and their associated TID and serial number length. This listing includes all assignments made pursuant to ASC INCITS 256.

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Table 7 – ISO/IEC 15963 Tag IDs including all ASC INCITS 256 assignments

	Total bits	Allocation Class (AC)	Tag ID registration number	Serial number
Standard		8 bits	*Size defined by AC value*	*Size defined by AC and UID value*
INCITS 256	64	000x xxxx		
INCITS 256, 18000-7	32	000x xxxx	000x xxxx	
ISO 18000-7	48	000x xxxx	xxxx xxxx	xxxx xxxx xxxx xxxx xxxx xxxx xxxx xxxx
ISO 18000-7 (Savi)	48	0001 0001	0000 0100	xxxx xxxx xxxx xxxx xxxx xxxx xxxx xxxx
ISO 18000-2, Type A (7816-6)	56 + AC	1110 0000	xxxx xxxx (per 7816-6)	xxxx xxxx xxxx xxxx xxxx xxxx xxxx xxxx xxxx xxxx xxxx xxxx
ISO 18000-3m3 (non-EPC)	16 - 496	1110 0000	xxxx xxxx xxxx - xxxx xxxx xxxx	Maximum 496 bits
ISO 18000-3m3 (EPC)	16 - 496	1110 0010	xxxx xxxx xxxx -xxxx xxxx xxxx	Maximum 496 bits
ISO 18000-4 (Intermec – 7816-6)	56	1110 0000	xxxx xxxx (per 7816-6)	xxxx xxxx xxxx xxxx xxxx xxxx xxxx xxxx xxxx xxxx xxxx xxxx
ISO 18000-4 (Intermec – 256)	56	0001 0010	xxxx xxxx (Unassigned)	xxxx xxxx xxxx xxxx xxxx xxxx xxxx xxxx xxxx xxxx xxxx xxxx
ISO 18000-4 (Siemens/Nedap 7816-6) (see 18000-4 for details)	32	N/A	xxxx xxxx (per 7816-6)	xxxx xxxx xxxx xxxx xxxx xxxx xxxx xxxx xxxx xxxx xxxx xxxx
ISO 18000-6A	64	1110 0010	xxxx xxxx xxxx - xxxx xxxx xxxx	xxxx xxxx xxxx xxxx xxxx xxxx xxxx xxxx
ISO 18000-6B	64	0001 0011	xxxx xxxx xxxx - xxxx xxxx xxxx	xxxx xxxx xxxx xxxx xxxx xxxx xxxx xxxx
ISO 18000-6C (7816)	64	1110 0000	(per 7816-6)	xxxx xxxx xxxx xxxx xxxx xxxx xxxx xxxx xxxx xxxx xxxx xxxx
ISO 18000-6C (EPC)	16 - 496	1110 0010	xxxx xxxx xxxx - xxxx xxxx xxxx	TBD - 18000-6C, Table 1 states a maximum of 496 bits
ISO/IEC 24730	48	0000 0000	xxxx - xxxx	xxxx xxxx xxxx xxxx xxxx xxxx xxxx xxxx
ISO/IEC 24730 (WhereNet)	48	0000 0000	0000 0000	xxxx xxxx xxxx xxxx xxxx xxxx xxxx xxxx

ISO/IEC 7816 describes how to encode a TID with ISO/IEC 15963's Allocation Class of "E0". Table 8 shows the format for an ISO/IEC 7816 TID. The first field after the Allocation Class is the TID issuer code. Table 9 shows the 7816-6 TID issuer codes assigned as of 2007-09-28.

Table 8 – ISO/IEC 7816-6 TID format

MSB LSB

64 57	56 49	48 1
"E0"	IC Mfg code	IC manufacturer serial number

Table 9 – ISO/IEC 7816-6 issuer codes (as of 2007-09-28)

Identifier	Company	Country
'01'	Motorola	UK
'02'	STMicroelectronics SA	France
'03'	Hitachi, Ltd	Japan
'04'	Philips Semiconductors	Germany
'05'	Infineon Technologies AG	Germany
'06'	Cylink	USA
'07'	Texas Instrument	France
'08'	Fujitsu Limited	Japan
'09'	Matsushita Electronics Corporation, Semiconductor Co.	Japan
'0A'	NEC	Japan
'0B'	Oki Electric Industry Co. Ltd	Japan
'0C'	Toshiba Corp.	Japan
'0D'	Mitsubishi Electric Corp.	Japan
'0E'	Samsung Electronics Co. Ltd	Korea
'0F'	Hynix	Korea
'10'	LG-Semiconductors Co. Ltd	Korea
'11'	Emosyn-EM Microelectronics	USA
'12'	INSIDE Technology	France
'13'	ORGA Kartensysteme GmbH	Germany
'14'	SHARP Corporation	Japan
'15'	ATMEL	France
'16'	EM Microelectronic-Marin SA	Switzerland
'17'	KSW Microtec GmbH	Germany
'18'	ZMD AG	Germany
'19'	XICOR, Inc.	USA
'1A'	Sony Corporation	Japan
'1B'	Malaysia Microelectronic Solutions Sdn. Bhd	Malaysia
'1C'	Emosyn	USA
'1D'	Shanghai Fudan Microelectronics Co. Ltd.	P.R. China
'1E'	Magellan Technology Pty Limited	Australia

Identifier	Company	Country
'1F'	Melexis NV BO	Switzerland
'20'	Renesas Technology Corp.	Japan
'21'	TAGSYS	France
22'	Transcore	USA
'23'	Shanghai belling corp., ltd.	China
'24'	Masktech Germany Gmbh	Germany
'25'	Innovision Research and Techology Plc	UK
'26'	Hitachi ULSI Systems Co., Ltd.	Japan
'27'	Cypak AB	Sweden
'28'	Ricoh	Japan
'29'	ASK	France
'2A'	Unicore Microsystems, LLC	Russian Federation
'2B'	Dallas Semiconductor/Maxim	USA
'2C'	Impinj, Inc.	USA
'2D'	RightPlug Alliance	USA
'2E'	Broadcom Corporation	USA
'2F'	MStar Semiconductor, Inc	Taiwan, ROC
'30'	eeDar Technology Inc.	USA
‘31’	RFIDsec	Denmark
‘32’	Schweizer Electronic AG	Germany
‘33’	AMIC Technology Corp	Taiwan

The EPCglobal Tag Data Standard describes how to encode a TID with ISO/IEC 15963’s Allocation Class of “E2”. Figure 6 shows the existing format for an EPC TID. Figure 7 shows the proposed format for an EPC TID. The first field after the Allocation Class is the TID issuer code. Table 10 shows the EPCglobal Tag mask-designer identifier code assignments.

TID MEM BANK BIT ADDRESS	BIT ADDRESS (In Hex)															
	0	1	2	3	4	5	6	7	8	9	A	B	C	D	E	F
10_h-$1F_h$	TAG MDID [3:0]				TAG MODEL NUMBER [11:0]											
00_h-$0F_h$	$E2_h$								XTID=0	TAG MDID [11:4]						

Figure 6 — EPCglobal Short TID

TID MEM BANK BIT ADDRESS	BIT ADDRESS (In Hex)															
	0	1	2	3	4	5	6	7	8	9	A	B	C	D	E	F
$E0_h$-EF_h	Sensor Memory Address [15:0]															
$D0_h$-DF_h	Sensor Memory Address [31:16]															
$C0_h$-CF_h	User Memory and BlockPermaLock [15:0]															
$B0_h$-BF_h	User Memory and BlockPermaLock [31:16]															
$A0_h$-AF_h	BlockWrite and BlockErase [15:0]															
90_h-$9F_h$	BlockWrite and BlockErase [31:16]															
80_h-$8F_h$	BlockWrite and BlockErase [47:32]															
70_h-$7F_h$	BlockWrite and BlockErase [63:48]															
60_h-$6F_h$	Optional Command Support [15:0]															
50_h-$5F_h$	Serial Number [15:0]															
40_h-$4F_h$	Serial Number [31:16]															
30_h-$3F_h$	Serial Number [47:32]															
20_h-$2F_h$	XTID Header [15:0]															
10_h-$1F_h$	TAG MDID[3:0]				TAG MODEL NUMBER [11:0]											
00_h-$0F_h$	$E2_h$								XTID=1	TAG MDID [11:4]						

Figure 7 — EPCglobal Extended TID

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Table 10 – EPCglobal task mask-designer codes (as of 2008-02-14)

Company	Decimal Value
Impinj	1
Texas Instruments	2
Alien Technology	3
Intelliflex	4
Atmel	5
Philips	6
ST Microelectronics	7
EP Microelectronics	8
Symbol Technologies	9
Sentech Snd Bhd	10
EM Microelectronics	11
Renesas Technology Corp.	12
Mstar	13
Tyco International	14
Quanray Electronics	15
Fujitsu	16

Top Arc of an Object Identifier (OID)

Another format for numbering has been recommended in meetings of the ITU-T. This recommendation is to encode a {joint-iso-itu} level arc for a service provider identification (SPID) in the format {joint-iso-itu-t(2) spid(28)} or “2.28”.

Four recommendations/standards are being considered by ITU-T

X.spid, Trusted Service Provider Identity (SPID)
This Recommendation | International Standard specifies the trusted Service Provider Identity system, including the construction of a SPID identifier within a new OID namespace {joint-iso-itu-t(2) spid(28)}. Q.10/17 and ISO/IEC JTC1/SC6 will jointly develop this text.

F.spid, Administration of Service Provider Identity
This Recommendation specifies how trusted SPID identity is maintained, including registration of service providers into the SPID Name System and associated Registry Information Service.

X.sns, SPID Name System (SNS)
This Recommendation | International Standard specifies a SPID identifier resolver system provided using BIND - similar to ENUM and EPCglobal's Object Name System platforms. The SNS would support a trusted, ultra high availability, low latency, distributed name system that resolves a SPID identifier to Dynamic Delegation Discovery System (DDDS) pointers to network based locations containing trusted SPID related network management identities (credentials, identifiers, attributes, and pattern representations) that are highly time-dependent. The specification will describe necessary pointer attributes and provide for alternative and extensible DDDS implementations.

X.sreg, SPID Registry Information Service (SREG)
This Recommendation specifies an XML based schema for accessing non-time-dependent, latency-tolerant SPID registration information. SREG is a specialized information type that uses existing Internet Registration Information Service (IRIS) specifications for discovery and secure response-query to available registry information.
This text will be developed in coordination with Q.2/17.

The implication of the use of the ITU-T proposed recommendations is that a new top arc would need to be added to all RF tag communications.

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IMPLICATIONS FOR THE FUTURE

The choices for a unique coding structure for the Internet of Things, as discussed above fall into three categories.

1. Use of Unique Item Identifier (UII)
2. Use of Unique Tag ID (TID)
3. Adding something new, e.g. OID Top Arc (SPID)

The impact of the third option is that all existing tags would be rendered obsolete and only tags that have the new encoding would be capable of “internet connectivity”. This implies that all silicon would need to be re-spun to add the new top arc.

The impact of the second option is that currently, in supply chain management applications, the first Memory Bank read is MB “01” encoding the UII, not MB “10” encoding the TID. For “internet connectivity” and if Unique Tag ID would be used, a separate read command would need to be issued or the protocol modified, as currently it backscatters PC+UII.

The impact of the first option is for a body such as ISO or ITU-T to take over the remaining EPCglobal headers to create a truly universal coding system that takes advantage of binary encoding as opposed to character-based encoding. EPCglobal cannot be the registrar for headers other than for its own use. It is proposed that EPCglobal be permitted 24 headers (10 more than they have already deployed). The remaining 232 headers would be controlled by ISO/ITU-T.

It is believed that the first option is the best option for a universal coding system for the Internet of Things.

Such coding would be similar as shown in Table 11.

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Table 11 – Proposed Table of ISO Header Values

	Header	Filter Value	Partition	Company Prefix	Asset Type	Serial Number
17363-96	8	3	3	20-40	24-4	38
	1000 0001 (Binary value)	(Refer to Table xx for values)	(Refer to Table xx for values)	999,999 – 999,999,999,999 (Max. decimal range)	999,999 – 0 (Max. decimal range)	274,877,906,943 (Max. decimal value)
	Header	Filter Value	Partition	Company Prefix	Asset Type	Serial Number
17364-96	8	3	3	20-40	24-4	38
	1000 0010 (Binary value)	(Refer to Table xx for values)	(Refer to Table xx for values)	999,999 – 999,999,999,999 (Max. decimal range)	999,999 – 0 (Max. decimal range)	274,877,906,943 (Max. decimal value)
	Header	Filter Value	Partition	Company Prefix	Serial Reference	Unallocated
17365-96	8	3	3	20-40	38-18	24
	1000 0011 (Binary value)	(Refer to Table xx for values)	(Refer to Table xx for values)	999,999 – 999,999,999,999 (Max. decimal range)	99,999,999,999 – 99,999 (Max. decimal range)	[Not Used]
	Header	Filter Value	Partition	Company Prefix	Item Reference	Serial Number
17366-96	8	3	3	20-40	24-4	38
	1000 0100 (Binary value)	(Refer to Table xx for values)	(Refer to Table xx for values)	999,999 – 999,999,999,999 (Max. decimal range)	9,999,999 – 9 (Max. decimal range)	274,877,906,943 (Max. decimal value)
	Header	Filter Value	Partition	Company Prefix	Item Reference	Serial Number
17367-96	8	3	3	20-40	24-4	38
	1000 0101 (Binary value)	(Refer to Table xx for values)	(Refer to Table xx for values)	999,999 – 999,999,999,999 (Max. decimal range)	9,999,999 – 9 (Max. decimal range)	274,877,906,943 (Max. decimal value)

Respectfully submitted,

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Annex

Ontology for Identification

Any tangible physical entity, or items as we shall now refer to them, may be represented by what may be called a state characteristic ($\hat{S}$). This characteristic comprises a set of quantities that characterises the item, or some aspect of the item, and its status with respect to prevailing conditions, and with respect to location and point-in-time. Symbolically, this can be expressed as

$$(q, \zeta, t) \in \hat{S} ;$$

where q, represents the intrinsic features or other attributes of the item that may be exploited in identifying, managing or transforming the item in some way, as in a process of some kind. The terms, ζ and t, represent the position in space (location) and time respectively. Change or variability in q with respect to these terms ($q = f[\zeta, t]$) may often be exploited as appropriate in process functionality. The features represented by q may also be functionally dependent upon prevailing conditions, such as temperature and humidity and may therefore constitute a variable with respect to these quantities too, and have to be considered as such.

1.1 Primary Identification

In seeking to exploit the state characteristic of an entity for identification purposes it is important to derive a feature set that is stable with respect to time, location and other dependent factors. It is also important for image-based identification to derive a set that exhibits rotational, scalable and translational (RST) invariance.

Where an item, or part of an item, exhibits static or stable features over the period for which it is to be considered these features may, depending upon the number and degrees of freedom that the features exhibit, be used to identify the item. As such the set of identification features will be a subset, q_{id}, of q.

$$(q_{id}, q, \zeta, t) \in \hat{S} \qquad q_{id} \subseteq q$$

Here q_{id} represents a natural item identifier that may be exploited in identifying, managing or transforming the item in a process function. While the terms ζ and t, are again included in the symbolic representation for identification purposes q_{id} should be independent of ζ and t. It is also necessary when considering a feature set (q_{id}) for identification purposes that the features should be readily accessible by appropriate sensing or information capture techniques. Biometrics are representative of this class of identifiers.

In these stark theoretical terms it may seem that such notation and techniques are somewhat remote from practical value. In reality, a number of these natural feature identification techniques are in current use. By way of example, the seemingly random matrix of fibres that form the micro-surface structure of a sheet of paper can be exploited for identification purposes, the fibres determining the amount of back scatter variation when scanned with a low-power laser beam. The signal derived in this way, analogous to a bar code scan, yields a ‘signature’ (q_{id}) that can be expressed in digital terms (sequence of bits) and used to uniquely identify the sheet of paper.

The state characteristic is intrinsic to any item and where a sub-set can be used to identity the item the identifier can also be linked to a body of knowledge or information about an item that exists or is generated to facilitate understanding, handling, processing or management of that item. This is very much a generalisation. The extent to which this characteristic or its components parts are exploited depends upon practicalities and economics. The practicalities relate to the granularity or resolution to which it is necessary to identify items and the means available and reasonable for identifying such entities.

Natural feature identification distinguished in this way may, for convenience, be considered as primary identification. Moreover, the techniques can be categorised with respect to the features or properties that are exploitable for identification purposes. So, for primary identification purposes features may be of physical, chemical or biological origin and derive from either static or dynamic phenomena.

1.2 Secondary identification

The alternative to natural feature identification is to use a data carrier in the form of an attendant physical entity, such as a tag or label, which can be embedded-in, attached-to, or accompany an item. The carrier is used to carry and provide an identity, typically in the form of a machine-readable number or alpha-numeric string stored within it. Identification in this form may be conveniently referred to as secondary identification.

Using this approach to item identification the item-attendant data carrier is linked in state terms to the item to which it is attached and both assumes the identity of the item and shares the influences of time and location experienced by the item. So the combination of item and item-attendant data carrier can now be represented essentially by a combined state characteristic:

$(ID_{dc}, q_i, q_{dc}, \zeta_i, t_i) \in \hat{S}$ Where dc denotes the data carrier and i the item.

While the data carrier itself will also exhibit intrinsic features (q_{dc}) they would not generally be exploited within a process function. However, they will have relevance to application needs with respect to features of durability and effectiveness of supporting data carrier functionality. It must also be recognised that the data carrier may also be capable of carrying additional data or information to that of the item identifier but of relevance to the item concerned. Where this capability is defined the combined state characteristic will include the additional data or information component:

$(ID_{dc}, D_{dc}, qi, q_{dc}, \zeta_i, t_i) \in \hat{S}$ where D_{dc} represents this additional data or information component.

A range of item-attendant data carriers is available, with differing form factors and attributes to suit a wide range of applications. These carriers include linear bar code symbols, two-dimensional coded symbols, contact and contact-less magnetically encoded carriers and both contact and non-contact semiconductor structures, including radio frequency identification (RFID).

While RFID is used as a secondary identifier and data carrier platform further types of devices may also provide the facility for sensory functions, using appropriate sensory and data storage or transfer components. This introduces a dynamic data capture feature with respect to the combined state characteristic, wherein the data component of the data carrier becomes a function relating to the sensor or sensors used for data capture and any data communication process that operates upon the data content:

$D_{dc} = f(\delta, D_s)$ where δ represents the sensory function and D_s the data storage feature.

Dynamism can also be distinguished for the intrinsic features of a RFID data carrier as a result of its radio functionality, giving rise to a 'radio signature' characteristic of a particular carrier. Thus q_{dc} may be considered to comprise a static and a dynamic term (q_{dcs}, q_{dcd}).

Anthony Furness
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