Cellular Networking Perspectives

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Text Me To Your Leader!

from the CWTA

On June 4th 2004 Canadians had their first ever opportunity to participate in live text messaging chats with the leaders of four major parties – the Liberals (the government party before the dissolution of the government), the Conservatives, the New Democrats and the Greens – which are currently in the midst of an election campaign culminating in voting on June 28th.

This was part of a program to encourage more voting by young Canadians who are about twice as apathetic (when it comes to voting) as their elders. Only about 25% of 18-24 year olds voted at the last federal election.

Latest US IMSI Assignment Guidelines

The latest IMSI assignment guidelines, that give US CDMA carriers the same right to 2-digit Mobile Network Codes as GSM carriers, are available at:

www.atis.org/ioc/guidelines.asp

Radio Frequency ID (RFID)

RFID (Radio Frequency Identification) is a term used for a broad range of technologies that use radio frequencies to communicate an identity to a scanner at close range. By some definitions, a cellular data module could even be RFID!

The majority of RFID uses, however, are designed to provide fewer capabilities than a cellular terminal. This is so they can be extremely cheap (under $1, although not yet quite cheap enough for some mass market applications). They can be used to provide the identity number for a library book, a rented uniform, a pet, a license plate or even a runner crossing the finish line.

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RFID devices differ widely in the amount of information they can hold, the speed and distance of reading and other capabilities, such as whether the information in them can be updated.

When compared to the older methods it replaces, such as bar codes, RFID provides a more sophisticated and more functional alternative, even though it is often more expensive. RFID can provide an enterprise greater efficiency, lower labour costs and more reliability. They are most beneficial when they can combine several functions formerly provided by separate technologies.

Table 1: Bar Codes Compared to RFID

Characteristic	Bar Codes	RFID
Transmission Medium	Reflected Light.	Radio Frequency.
Position of Tag	Surface of Object.	On or within object.
Robustness	Medium (due to its position on the surface).	High (especially when embedded within the object or wrapped in a protective layer).
Cost	Very low.	~50 cents to tens of dollars.
Line of sight	Required for reading.	Not necessary.
Interference potential	Very low.	Moderate.
Reading speed	Manual (e.g. measured in seconds).	Up to hundreds of reads per second.
Updating	Tag replacement.	Wireless reprogramming possible with *some* tags.
Reading distance	Inches or less.	From several inches to hundreds of feet.
Information storage potential	Tens of digits.	32 bits (about 10 digits) to Megabytes.

Applications

Applications for RFID are as widespread as the applications for cellular have become. They can be used in industrial laundries to allow automated sorting of laundry or to replace less robust bar codes. Libraries can use RFID for identification as well as theft control. Athletic events can use them to automate timing. ‘Smart shelves’ at a grocery or department store contain an RFID reader that, by regular scanning, can determine when products are placed on the shelf, and when they are removed. This can help reduce loss through theft and make restocking more efficient.

Shipments of goods may be placed on pallets that can regularly perform RFID scans to identify the goods placed on them. Later they can communicate that information to inform the manufacturer, purchaser and the shipping company of the progress of the goods.

License plates can be made fraud resistant by embedding an RFID tag. Tags can be used to simplify processing by frequent users of automated toll highways and border crossings. RFID tags in cars can provide a more tamper-resistant identity than a stamped metal vehicle identification number.

Prisoners under house arrest may be monitored by an RFID reader that will generate an alarm if the tag leaves a defined area. Employee tags can be RFID, as this technology eases the opening of doors in a facility, but also ensures that high security areas are not breached by unauthorized employees.

Pets commonly have RFID tags embedded in them, increasing the likelihood that they will be returned to their owners if they become lost.

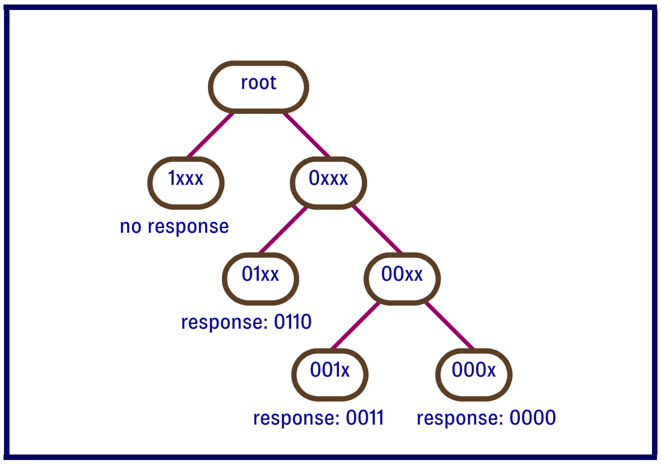
RFID Types

At their simplest, ‘passive’ RFID tags are powered by induction due to a magnet in the ‘antenna’ of an RFID reader. The motion of the magnetic field as the reader is waved past the tag (or the tagged object moves past the reader, perhaps on a conveyer belt) induces an electrical current, which powers the tiny logic circuit in the tag, which then emits a radio signal containing the identification number, a string of from 32 to 128 bits. Radio transmission is usually in the 100-500 Khz range, and the tags can only be read with the reader a few inches away.

More sophisticated ‘active’ tags are more expensive, but can overcome many of the limitations of passive tags. They usually have a battery, and can receive a command over the radio link, as well as use radio waves to transmit. These systems usually operate in the 850-950 MHz or 2.4-5.8 GHz range. They have the ability to store significantly larger amounts of data, up to megabytes worth in some cases, can transmit it much faster, and sometimes can receive commands to update their memory as well.

Active RFID tags can be read individually by transmitting their identification number, plus a command. However, this is only useful when you know the number of the tag. What is sometimes more useful is to read multiple tags without knowing the number of any of them. This is often done with a tree-walking algorithm. The reader will transmit a short prefix and all tags that match will respond. It will then add one more bit to the prefix, which splits the group of tags into two. Eventually it will find out that it has addressed an individual tag (because the response will not be corrupted by interference). This allows efficient reading of a group of tags with unknown ids. As illustrated in **Figure 1**, if there were three tags with 4-bit codes of 0000, 0011 and 0110, the reader would first transmit a "1" and get no response, then a "0" and get multiple responses, then "01" and get only a single response from 0110. Knowing that more tags still remain unread (because of the multiple responses when the first bit was set to 0), the reader will broadcast "00" and again get multiple responses. It then will broadcast 001 and receive the single response 0011 in return, and then broadcast 000 and receive 0000 in return. Three tags have been read with 6 read/write cycles, even though there are 16 possible combinations of 4-bit identification numbers. With identification numbers that are 32 bits or longer, the savings are exponentially larger.

Figure 1: Tree Walking



Current Directions

Several large organizations, most notably Wal-Mart and the US Department of Defence, have recently indicated that they may soon require all products they purchase to be tagged. Their dream, and that of many others, is for the RFID tag to be read at various places from the manufacturing plant, trans-shipping operations, warehouses and at the retail store until finally being deactivated at checkout. This will give unprecedented visibility along the supply chain.

There are a number of challenges to this dream. One is that the use of a common tag for many products can require the integration of a company's databases, and often that is a more significant undertaking than expected. It will require companies to exchange more information, requiring more sophisticated and secure inter-working. Standardization has been the bane of RFID. Even AIM (Association for Automatic Identification and Mobility), a trade association for RFID vendors, admits that a lack of open standards (or even *de facto* standards) has crippled RFID industry growth and stalled the price reductions that come with mass production.

There has been some progress. ISO standards 11784/11785 have been developed for the identification of animals, and ANSI X3T6 has written a standard for 2.45 GHz RFID tag operation. It is likely that large organizations like Wal-Mart will impose their own specifications giving standardization a bigger boost than standards organizations have been able to do.

Privacy and Security

Many consumers, politicians and lawyers are convinced that RFID is a major privacy risk, that people can be tracked and associated with their buying habits based on the RFID identities of objects they have with them.

This is largely a false notion because of the lack of standardization of RFID, the short range of the devices and the need to have access to multiple corporate databases to interpret all the identifiers. This is not to say that privacy is not a concern. Under special circumstances it could be a big concern, but normally 'Big Brother' would not have the money to put in the massive number of RFID readers required, and the monitoring would be easy to circumvent. See the April issue of *Wireless Security Perspectives* for more information.

The best way for companies to defuse this concern is to provide consumers with adequate information, indicating how RFID tags are disabled by the company or can be disabled by the consumer.

RSA, the well known security company, has proposed a device that jams RFID readers by responding to every request with a partial identification. This would mean, for example, that four billion operations would be required to read 32-bit tags, even if only 3 of them were in the vicinity. The blocker merely responds affirmatively to every request with an identification prefix (as opposed to a complete identity), forcing the reader to search every branch of the tree while still allowing queries of tags based on a full identification.

Privacy concerns may put the brakes on thoughts of using one tag for multiple purposes. A single tag on a vehicle to replace the license plate, vehicle identification number and automated toll gates could easily be misused, especially if the multiple databases containing the tag's id number were interconnected, or all accessible by the same organization. Even single-purpose databases of RFID identifications must be protected.

The Importance of Price

Tags might seem to be quite cheap, passive tags often being in the 50 cent range (although prices go much higher for more sophisticated tags), but the industry's goal is to produce a simple tag for 5 cents. At this price, tags can be embedded in just about anything. The *RFID Journal* has estimated that manufacturing volumes and technological advances will allow this price point to be met in 2007.

Conclusions

RFID tags are already in widespread use, but increased standardization, adoption by large organizations and the consequent reduced costs will make them even more pervasive. Once standards (formal or *de facto*) have been widely accepted, and more software tools and hardware modules are available, RFID will become much more useful for medium and small organizations. For consumer applications, issues of privacy and security will have to be resolved to avoid restrictive legislation.

To Probe Further

EPCglobal – Industry-driven RFID Standards

www.epcglobalinc.org

RFID Journal – Online daily RFID news source.

www.rfidjournal.com

International Standards Organization (ISO)

www.iso.org/iso/en/ISOOnline.frontpage

Association for Automatic Identification and Mobility (AIM) – Trade Association

www.aimglobal.org

RSA – Security Company

www.rsasecurity.com/node.asp?id=1367

Comments

We welcome comments on the format or contents of *Cellular Networking Perspectives*. We can be reached via email at:

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3GPP TSG Radio Access Network (RAN) Update

3GPP TSG for Radio Access Networks (TSG RAN) defines the functions, requirements and interfaces for the UTRA network (UTRAN) in its FDD and TDD modes, including radio performance, physical layer, layer 2 and layer 3 RR, the access network interfaces (Iu, Iub and Iur), O&M requirements and conformance testing for Base Stations.

One TSG RAN meeting (#23) has been held since our last update.

TSG RAN Working Group 1 (Radio Layer 1)

TSG RAN Working Group 1 (RAN1) defines the physical layer of the radio interface between mobile phones (UE) and the UTRAN, including specification of physical channel structures, mapping of transport channels to physical channels, spreading, modulation, physical layer multiplexing, channel coding and error detection. Physical layer procedures and the measurements provided to upper layers are also specified by RAN1.

Highlights of RAN1 meeting #23 were:

- The *Enhanced Uplink Dedicated Channel* Study Item was concluded, resulting in the new TR 25.896 being approved for Release 6. RAN1 also recommended creation of a new work item on WCDM Uplink Enhancements covering:
  - » Node B controlled scheduling.
  - » Hybrid Automatic Repeat Request (HARQ).
  - » Shorter Transmission Timing Interval (TTI).

  RAN1 decided not to propose work on higher order modulation using 8PSK (or higher) or Fast Dedicated Channel (DCH) set up.
- A draft Technical Report for the Work Item (WI) for Uplink Enhancements for UTRA TDD was accepted.
- The *Analysis of OFDM for UTRAN Enhancement* study item should be completed in June 2004.
- Work Item for *Multiple Input Multiple Out* (TR 25.876) is scheduled for completion in September 2004. The other RAN working groups have been delayed because of dependencies on the slow work in RAN1.
- The Work Item on the Transmit diversity solutions for multiple Antennas had no contributions, stalling progress.

- RAN continues to debate HSDPA Enhancements, particularly the clarification of High Speed – Dedicated Physical Control Channel (HS-DPCCH) transmission under reconfiguration. The questions in the debate are:
  - » When should the User Equipment transmit the Channel Quality Indicator in relation to transmission of the uplink DPCCH?
  - » When should Discontinuous Transmission (DTX) be used instead of ACK/NAK and Channel Quality Indicator (CQI) reporting?
- Panasonic, Philips and Nokia have a contribution proposing a list of times when the UE should not transmit. Ericsson has a document that analyses if it is necessary to use DTX and stop ACK/NAK and CQI report. For some reconfiguration events, an ambiguity can be produced, and hence the UE should not always report them.

The following design principles have been adopted for the WI for TR 25.803 – Multimedia Broadcast/Multicast Service (MBMS):

- » Analysis of UE complexity for selective combining (soft handoff) is ongoing.
- » 256 kbit/s is the maximum downlink bit rate (from the BTS to the UE) with acceptable power consumption.
- » An uplink maximum bit rate of 64 kbit/s results in acceptable complexity at the UE. Higher uplink bit rates are under study.
- » No performance benefits were found in Outer Coding which had been proposed as new error control at Layer 2.
- » When a UE using MBMS is on the edge of a cell, it should continue measuring neighboring cells to ensure that it hands off when necessary to maintain optimal performance.

Table 2: 3GPP TSG RAN Working Group 1 Specification Update (Physical Layer)

Document	Title	Status
tbd	Optimization of Downlink Channelization Code Utilization	New work items
tbd	Optimization of Channelization Code Utilization for TDD.	
TS 25.212	Multiplexing and Channel Coding (FDD)	Rel 5, Rel 6 being revised.
TS 25.214	Physical Layer Procedures (FDD)	
TS 25.225	Physical Layer – Measurements (TDD)	Rel 4, Rel 5, Rel 6 being revised.
TR 25.887	Beam-forming Enhancements	Rel 6 available.
TR 25.892	Feasibility Study for OFDM for UTRAN Enhancement	Under development.
TR 25.896	Feasibility Study for Enhanced Uplink for UTRA FDD	Rel 6 available.

TSG RAN Working Group 2 (Radio Layer 2 and Radio Layer 3 RR)

TSG RAN Working Group 2 (RAN2) defines the Radio Interface architecture and protocols (MAC, RLC, PDCP), the Radio Resource Control protocol, the strategies for Radio Resource Management and the services provided by the physical layer to the upper layers.

Most major architecture decisions for the Work Item on Multimedia Broadcast/Multicast Service (MBMS) have been made and there will be no Stage 3 impact.

Future meetings will focus on Pre-Release 6 corrections, MBMS, IMS support and other Release 6 work items.

Nortel proposed to create TR 25.998 “UTRAN Recommendation and UE Allowance for Non-Essential Corrections of a Feature made only in a Later Release”. Its purpose would be to capture the list of late corrections which could be delayed until after a frozen release was completed. Also, for each approved error identified, it would indicate how they could be incorporated into earlier releases. This new report was contested by some UE manufactures as it would result in a document outside the core specifications that developers would need to take into account during implementation. Instead of this, it was agreed to add the following statement to CRs that implement corrections that would have been introduced in a previous release if discovered on time (and that are compatible with earlier releases): *Implementation of this CR by a Release XX UE will not cause compatibility issues*.

RAN2 agreed to freeze the Rel 5 TS 23.331 ASN.1 protocol specification by June 2004.

A draft of TR 25.862 for the Work Item on Radio Access Bearer Support Enhancement includes the following principles:

- IETF RFC 3095 Robust Header Compression (ROHC) will be Mandatory (for UEs that support IMS).
- It is necessary to precisely define ROHC usage to maximize performance (especially for VoIP).

Table 3: 3GPP TSG RAN2 (Radio Layer 2 and Radio Layer 3 RR) Specification Update

Document	Title	Status
tbd	FDD Enhanced Uplink	New work item.
TS 25.302	Services Provided by the Physical Layer	Rel 6 being revised.
TS 25.304	UE Procedures in Idle Mode and Procedures for Cell Reselection in Connected Mode	Rel 99, Rel 4, Rel 5, Rel 6 being revised.
TS 25.306	UE Radio Access Capabilities	Rel 5 and Rel 6 being revised.
TS 25.308	High Speed Downlink Packet Access (HSDPA); Overall Description; Stage 2	Rel 5 and Rel 6 being revised.
TS 25.321	MAC Protocol Specification	
TS 25.331	RRC Protocol Specification	Rel 6 being revised.
TS 25.346	Introduction of Multimedia Broadcast Multicast Service (MBMS) in the Radio Access Network (RAN); Stage 2	Rel 6 available.
TR 25.862	RAB Support for IMS	
TR 25.921	Guidelines and Principles for Protocol Description and Error Handling	Rel 99, Rel 4 and Rel 5 being revised.
TR 25.922	Radio Resource Management Strategies	

TSG RAN WG3 (UTRAN Architecture)

TSG RAN Working Group 3 (RAN3) defines the Overall UTRAN architecture, protocols for the Iu, Iur, Iub interfaces and the use of IP protocol for the transport layer in UTRAN.

RAN3 had an action item from the previous TSG meeting to study ATM/IP Interworking. It endorsed two different options:

- ITU-T recommendation Q.2631.1 for connection control signalling.
- PWE3 (pseudo wire emulation).

Many contributions for High Speed Downlink Packet Access (HSDPA) Iub/Iur Protocol Aspects were incorporated into the technical specifications.

The Work Item on *Network Assisted Cell Change (NACC) from UTRAN to GERAN – Network Side Aspects* Stage 2 work has been completed and Stage 3 work has been initiated.

RAN3 is waiting for a decision from SA2 and CN working groups on the open issues of how the RAN distinguishes between SIP user and signalling traffic for those Radio Access Bearers which are supposed to carry signalling traffic only.

For the *Remote Control of Electrical Tilting Antennas,* RAN3 has agreed on how the UTRAN architecture and protocol structure will be impacted. There are, however, still open issues on Layer 1 and Layer 2 aspects. A new TS 25.4xx specification will incorporate this.

RAN3 still has two decisions to be made on the *Subscriber and Equipment Trace Support in RAN* work item:

- Choosing one of two methods for management-based activation.
- Whether to support tracing in the Drift Radio Network Controller (DRNC) in Rel 6.

RAN3 completed its work item on *Improved Access to UE Measurement Data for Controlling Radio Network Controller (CRNC) to Support TDD Radio Resource Management.*

The study item on the evolution of the UTRAN Architecture was discussed. Some companies requested to close it due to the lack of agreement on a number of meetings, but others wanted more time for discussion of the many contributions still being presented. The nature of contributions discussed in RAN3 does not seem to fall under the scope of study, which is supposed to focus on an all-IP network. It was finally agreed to continue the work, but not until MBMS is finished.

TSG RAN Working Group 4 (Radio Performance and Protocol)

TSG RAN Working Group 4 (RAN4) defines the RF aspects of UTRAN, including simulations of RF system scenarios and derivation of the minimum requirements for transmission, receiving and channel demodulation. From these requirements, the group writes test procedures to verify them. Requirements for other radio elements, like Repeaters, are specified in RAN4 as well.

At the most recent meeting there was discussion of the release of CRs to provide test cases for a previously agreed-to requirement for Transmit Power Control (TPC) commands combining when in Soft Hand Over in Rel 99, Rel 4, Rel 5 and Rel 6. TSG RAN decided that manufacturers would not be required to implement these new commands, but were free to do so “at the earliest pragmatic opportunity.”

Table 4: 3GPP TSG RAN Working Group 3 (UTRAN Architecture) Specification Update

Document	Title	Status
TS 25.413	UTRAN Iu Interface RANAP Signalling	Rel 4, Rel 5 and Rel 6 being revised.
TS 25.419	UTRAN Iu-BC Interface: Service Area Broadcast Protocol	Rel 5 and Rel 6 being revised.
TS 25.424	UTRAN Iur Interface Data Transport & Transport Signalling for Common Transport Channel Data Streams	
TS 25.425	UTRAN Iur Interface User Plane Protocols for Common Transport Channel Data Streams	
TS 25.426	UTRAN Iur and Iub Interface Data Transport & Transport Signalling for DCH Data Streams	
TS 25.433	UTRAN Iub Interface NBAP Signalling	Rel 4, Rel 5 and Rel 6 being revised.
TS 25.434	UTRAN Iub Interface Data Transport and Transport Signalling for Common Transport Channel Data Streams	Rel 5 and Rel 6 being revised.
TS 25.435	UTRAN Iub Interface User Plane Protocols for Common Transport Channel Data Streams	
TR 25.807	Low Output Powers for General Purpose Frequency Division Duplex (FDD) Base Station (BS)	Rel 6 available.

Table 5: 3GPP TSG RAN WG 4 (Radio Performance and Protocol) Specification Update

Document	Title	Status
TS 25.101	UE Radio Transmission and Reception (FDD)	Rel 5 and Rel 6 being revised.
TS 25.104	UTRA (BS) FDD; Radio Transmission and Reception	Rel 6 being revised.
TS 25.123	Requirements for Support of Radio Resource Management (TDD)	Rel 4, Rel 5 and Rel 6 being revised.
TS 25.141	Base Station Conformance Testing (FDD)	Rel 5 being revised.
TR 25.806	UMTS 1700/2100 MHz Work Item Technical Report	Rel 6 available.
TR 25.942	Radio Frequency (RF) System Scenario	Rel 5 and Rel 6 being revised.
TR 25.945	RF requirements for 1.28 Mcps UTRA TDD Option	Rel 5 being revised.
TS 34.124	Electromagnetic Compatibility (EMC) Requirements for Mobile Terminals and Ancillary Equipment	
TR 34.926	Electromagnetic compatibility (EMC) Table of International Requirements for Mobile Terminals and Ancillary Equipment	

Meeting Schedule

The most recent plenary meeting of TSG RAN was held March 10 – 12, 2004 in Phoenix, USA.

Future meetings are planned for:

- June 2 – 4, 2004 in Seoul, Korea.
- September 8 – 10, 2004 in Palm Springs, USA.
- December 8 – 10, 2004 in Athens, Greece.
- March 9 – 11, 2005 in Tokyo, Japan.
- June 1 – 3, 2005.
- September 7 – 9, 2005.
- November 30 – December 2, 2005.

Additional RAN1 and RAN4 meetings outside this schedule are planned for:

- August 16 – 20, 2004 in Prague, Czech Republic.
- November 15 – 19, 2004 in Shin Yokohama, Japan.

Extra RAN2 and RAN3 meetings are planned for:

- August 16 – 20, 2004 in Prague, Czech Republic.
- October 4 – 8, 2004 in Sophia Antipolis, France.
- November 15 – 19, 2004 in Shin Yokohama, Japan.

For a complete schedule of 3GPP meetings, consult:

www.3gpp.org/Meetings/meetings.htm

TIA TR-45.4/3GPP2 TSG-A Radio Access Network Interface Standards

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Note: 1. IS- Interim Standard, TSB- Telecommunications Systems Bulletin, PN- Project Number, SP- ANSI Standards Proposal, A.Pxxxx - TSG-A project, A.Rxxxx - TSG-A report, A.Sxxxx - TSG-A specification. Due to space considerations projects of the format PN-3-xxxx are shown without the "-3" (which means 'TIA').
2. Bold Type indicates a modification since the previous publication of this information.
3. Published TIA standards can be obtained from TIA at www.tiaonline.org/standards/search_n_order.cfm.

3GPP2 TSG-A Projects (P.xxxx), Specifications (S.xxxx) and Reports (R.xxxx)

Standard	Title	Status
A.R0003	Abis interface technical report for CDMA2000 systems. Refer to A.S0003	Completed 12/99
A.R0006	Study of IP-based RAN architecture for CDMA2000	Completed 07/01
A.R0011	Report on issues identified with IOS V4.1	Completed 08/02
A.S0001	**Interoperability specification (IOS) for CDMA2000**	**Published 06/00**
A.S0001-A	Interoperability specification (IOS) for CDMA2000	Published 06/01
A.S0003	BTS-BSC interoperability (Abis interface) for CDMA2000	Published 03/00
A.S0003-A	BTS-BSC (Abis) interface for CDMA2000	Published 07/01
A.S0004	**CDMA/TDMA Tandem Free Operation - Refer to TIA/EIA-829**	**Published 01/01**
A.S0004-A	CDMA/TDMA Tandem Free Operation - Refer to TIA/EIA-895	Published 03/02
A.S0004-B	CDMA Tandem Free Operations. Refer to TIA/EIA-895-A	Published 08/02
A.S0007	HRPD Interoperability specification (IOS) for CDMA2000 (Phase 1). Refer to TIA-878	Published 11/01
A.S0007-A	HRPD IOS (Phase 2). Session Control/Mobility Management in PCF. Refer to TIA-1878	Published 05/03
A.S0008	HRPD IOS. Refer to TIA-878-1	Published 05/03
A.S0011~17	Interoperability specification (IOS) for CDMA2000. In 7 parts (see below)	See TIA-2001-B
A.S0011	Part 1 - Overview	
A.S0012	Part 2 - Transport	
A.S0013	Part 3 - Features	
A.S0014	Part 4 - A1, A2, A5 interfaces	
A.S0015	Part 5 - A3, A7 interfaces	
A.S0016	Part 6 - A8, A9 interfaces	
A.S0017	Part 7 - A10, A11 interfaces	
A.S0011~17-A	Interoperability specifications (IOS v4.3) for CDMA2000 in 7 parts	See TIA-2001-C
A.S0011~17-B	**Interoperability specifications (IOS v4.3.1) for CDMA2000 in 7 parts**	**See TIA-2001-D**

TR-45.4 Projects and Standards

Standard	Project	Title	Status
TIA/EIA-828	SP-4604	Abis interface specification for CDMA2000	Published 12/01
TIA/EIA-829	PN-4683	Tandem Free Operation (bypasses intermediate vocoders in mobile-to-mobile calls with compatible vocoders)	Published 08/01
TIA/EIA-895	SP-0030	CDMA Tandem Free Operation	Published 03/02
IS-658	PN-4374	Data Services Interworking Function Interface (e.g.modempool). This version developed by TR-45.5	Published 07/96
IS-658-1	PN-4385	Extends the ability to perform interface status exchange at times other than call setup	Published 02/99
TIA-878	PN-0009	HRPD interoperability specification (IOS) for CDMA2000 “A” interface	Published 12/01
TIA-878-1	PN-0009-AD1-A	Addendum to HRPD IOS	Published 05/03
TIA-895-A	SP-0030-RV1	CDMA Tandem Free Operation	Published 10/02
TIA-1878	PN-0091	IOS for high rate packet data (HRPD) - Alternative architecture	Published 08/03
TIA-1878-A	**PN-0091**	**IOS for high rate packet data (HRPD) - Alternative architecture**	**Development**
TSB-80		IS-634-0 Addendum (corrections, SMS, subrate voice frame format)	Published 11/96
TSB-104		PCS Service Description (now IS-104 in committee TR-46)	Published 06/94
IS-2001	PN-4545	CDMA2000 Access Network Interface ("A" Interface) based on 3GPP2 TSG-A IOS V4.0	Published 12/00
IS-2001-1	PN-4545-AD1	Errata sheet for IS-2001	Published 05/01
IS-2001-A	PN-4545-RV1	CDMA2000 Access Network Interface based on IOS v4.1	Published 08/01
TIA-2001-B	SP-4545-RV2	CDMA2000 Access Network Interface based on IOS v4.2	Published 05/02
TIA-2001-C	**SP-4545-RV3**	**CDMA2000 Access Network Interface based on IOS v4.3**	**Published 12/03**
TIA-2001-D		**CDMA2000 Access Network Interface based on IOS v4.3.1**	**Ballot**
IS-634-0	PN-3296	MSC-BS "A" Interface Standard	Published 12/95
IS-634-A	PN-3539	MSC-BS Interface, including support for IS-95-A, EIA/TIA-553-A, IS-41-C, SMS, data and frame relay	Published 10/98
TIA/EIA-634-B	SP-4277	ANSI version of IS-634-A	Published 04/99