**The Technical Case For Convergence Of Third Generation
Wireless Systems Based On CDMA**
--Five Key Technical Principles To Consider --

The wireless industry is actively addressing the evolution of technology to

support third generation IMT-2000 systems, systems that will offer high burst rate

packet communications in addition to high quality voice and medium rate data. Several

radio technology proposals have been put forth and virtually all are based on direct

sequence spread spectrum Code Division Multiple Access (CDMA) digital wireless

technology. As the first in the world to develop this technology for commercial use, and,

as a result, the inventor and patent holder of the core technologies enabling efficient

commercial application, QUALCOMM welcomes and supports this recognition of the

overwhelming advantages of CDMA over earlier technologies. The present generation of

CDMA, denoted as cdmaOne®[1], has been standardized and is in widespread use for

cellular, personal communications, and wireless local loop in many countries. CDMA is a

proven technology, providing the highest voice quality, and rapidly evolving to support

efficient medium rate data. Many companies including QUALCOMM are working on a

multi-bandwidth evolution of cdmaOne, denoted as cdma2000®[2] (previously called

Wideband cdmaOne™). Others are working on a variation of CDMA denoted W-CDMA,

using core technology from cdmaOne but with a number of different choices for

parameters and technical details. QUALCOMM believes these proposals should be

converged to a single, global third generation standard working equally well with both

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[1] cdmaOne® is a registered mark of the CDMA Development Group (CDG)
[2] cdma2000® is a registered mark of the Telecommunications Industry Association (TIA)

major mobile networks, GSM-MAP and TIA/EIA-41 (commonly called IS-41 or ANSI-41), for the benefit of service providers and customers worldwide.

Following are five key technical principles that QUALCOMM believes should be addressed by the wireless industry for successful global convergence of CDMA proposals to achieve the highest quality, greatest spectral efficiency and most cost effective service.

Principle #1 - A single chip rate of 3.6864 Megachips per second should be used for the 5 MHz bandwidth

A key requirement for third generation systems is the ability to support IMT-2000 services in spectrum allocations of 5 MHz x 2 (i.e., the network operator has multiples of 5 MHz allocated for the transmit channel and equal 5 MHz multiples allocated for the receive channel). This is true for the D, E, and F band Personal Communications Services (PCS) operators in the U.S. and may also be true in other countries where regulators may partition IMT-2000 spectrum into similar-sized spectrum segments or choose to phase in the allocation of new spectrum. The objective is to fit the wideband CDMA carrier within this allocation, while still allowing for the requisite guard band (a narrow bandwidth between adjacent channels which serves to reduce interference between those adjacent channels) between this carrier and any adjacent uncoordinated carrier.

Significant debate has ensued around the choice of the *chip rate*, which in simple terms, determines the degree of spreading for the CDMA signal. The chip rate, therefore,

impacts the carrier spacing and the resultant system capacity. Standard band CDMA TIA/EIA-95 (previously called IS-95) utilizes 1.2288 Megachips per second (Mcps) as the chip rate, resulting in a bandwidth of slightly less than 1.25 MHz. For third generation systems, a chip rate of 3.6864 Mcps has been specified for a variety of reasons. The most obvious is the fact that it fits well into the 5 MHz band allocation, allowing a minimum of 250 kHz as a guard band to be provisioned on either side in order to prevent interference with any adjacent uncoordinated operators. This is not true of the 4.096 Mcps chip rate that has been specified for the competing W-CDMA proposal, which results in a guard band of 0 kHz, making it unacceptable from a spectral emissions perspective. The 3.6864 Mcps value is also 3 x 1.2288, a multiple of the current CDMA chip rate, allowing greater compatibility with the systems now being manufactured and deployed worldwide. The cdma2000 proposal allows two approaches on the forward link, a multi-carrier option and a direct-spread option. A chip rate of 3.6864 Mcps supports both these options and supports a flexible third generation overlay of today's cdmaOne (TIA/EIA-95) systems and, most importantly, equal or greater efficiency in new green field spectrum.

The grievances voiced by the North American GSM Alliance on the third generation convergence issue and their opposition to the 3.6864 Mcps chip rate stem from their desire to prevent ease of transition to third generation systems for the cdmaOne operators, and thereby avoid a competitive disadvantage for GSM operators arising from their choice of GSM technology. It is certainly true that use of CDMA in second generation, either initially or following a transition, provides a competitive

advantage to use of CDMA in third generation. The power of CDMA should not be weakened in an attempt to somewhat weaken these advantages.

The analysis for the 3.6864 Mcps based wideband CDMA system permits the deployment of five wideband CDMA carriers in a 20 MHz x 2 band allocation, with a minimum guard band of 250 kHz on either side of the band. The choice of a 4.096 Mcps chip rate on the other hand allows for only four wideband CDMA carriers in the same 20 MHz allocation, with no guard band at all. In fact, there is significant concern that provisioning four carriers will overlap the edges of the 20 MHz band, potentially causing interference in the adjacent band.

In countries where cdmaOne (TIA/EIA-95) deployments exist, the operators could mix the wideband channel with the standard band 1.25 MHz channels, enabling them to provide a greater mix of differentiated voice and data services. In the 15 MHz x 2 band allocation (used in Region 2 and under consideration for new allocations in some countries), choosing 3.6864 Mcps allows the operator to fit three wideband CDMA carriers and additional standard band CDMA carriers. Choosing 4.096 Mcps yields the capability to support at most three wideband carriers.

A "compromise" chip rate, 3.84 Mcps, has also been proposed. This change from 3.6864 Mcps is driven by the advocates of competitive disadvantage, and this change would achieve their goal without providing any technical advantage. Thus, it is not a compromise. The 3.6864 Mcps chip rate has true claim for acceptance in the converged standard because it builds on the 100 million or more CDMA subscribers expected by the time IMT-2000 services are offered commercially, currently targeted for 2002.

The choice of chip rate has also been incorrectly linked by some opponents of convergence to the issue of Intellectual Property Rights (IPR). This linkage is erroneous and misleading since the selection of the chip rate does not make QUALCOMM's IPR any more or less applicable. Dual chip-rate options have also been discussed to resolve the political issue of chip rate selection. A dual chip rate option unnecessarily complicates the implementation of the handset.

Conclusion: QUALCOMM urges the adoption of the 3.6864 Mcps as the single chip rate for the converged standard.

Principle # 2 - Existing cdmaOne service and signaling for ANSI-41 must be accommodated, allowing for phones both with and without SIM cards

In accordance with the International Telecommunications Union's (ITU) "Family of Systems" concept, QUALCOMM believes that any true third generation standard must support both existing cdmaOne services (supported through ANSI-41) and GSM services (supported through the GSM MAP protocol) without 'interworking' (i.e., without dependence on switch-external 'hardware and software box' implementations that inadequately adapt services of cdmaOne systems to services of GSM and vice-versa). Dependence on interworking removes the responsibility of accommodating existing services of either system from the Mobile Switching Center (MSC) of the other. Current experience with such interworking implementations has generally not been positive.

For the support of cdmaOne services, this would include the IS-127 (EVRC) speech codec, IS-733 (13 kbps) speech codec, IS-707 data services, IS-637 short messaging, and IS-683 over-the-air service provisioning. Appropriate air interface signaling to support ANSI-41 features and services must be efficiently supported.

The ITU has defined a User Identity Module (UIM) function that is associated with subscriber information and authentication in the network. The need for UIM support is a functional requirement and is not tied to a specific physical implementation of the function. The UIM function should be allowed to be implemented with or without Subscriber Identity Module (SIM) cards, also known as 'chip cards.' SIM cards have been predominantly used by GSM systems. Elsewhere, non-card based methods for subscriber management are widely in use, and new methods continue to be developed for future implementation. Neither of the two physical approaches, card-based or non-card based, should be mandated in the converged standard to the exclusion of the other. The operator should have the flexibility to choose and third generation systems should accommodate both.

Conclusion: QUALCOMM understands and fully accepts that GSM operators and manufacturers require compatibility with GSM services and GSM-MAP in the same way that cdmaOne operators and manufacturers require compatibility with cdmaOne services and ANSI-41. QUALCOMM believes that third generation standards should support both cdmaOne and GSM services and networks equally. QUALCOMM also supports the evolutionary development of new services and the convergence of cdmaOne

and GSM services and networks, and recognizes that most high burst rate traffic will be destined for the Internet using internationally accepted Internet protocols.

Principle # 3 - Synchronous base station transmission of a shared, time-shifted code-division continuous pilot should be used on each forward beam

CDMA technology has successfully benefited by keeping base stations synchronized to a common time reference. The Global Positioning Satellite System (GPS) has been utilized for this purpose in cdmaOne deployments. Alternative methods for synchronization are also being investigated and some proposals have been made for use in cdma2000 systems.

The competing W-CDMA proposal stipulates asynchronous base station operation. The rationale for proposing asynchronous systems over synchronous systems has been stated to be 1) to avoid GPS based synchronization methods and 2) to overcome the alleged difficulty of providing an external synchronization source for micro base stations or pico base stations in buildings or underground subway stations. QUALCOMM has participated in discussions on the merits of synchronous versus asynchronous base station approaches. It is well known that, however implemented, synchronized operation yields better CDMA system performance with less mobile station complexity (for example, in handoff scenarios). Further, GPS is the simplest, most economical, accurate and omnipresent source of timing for synchronization and frequency maintenance. Synchronization schemes other than GPS have been proposed

and can be deployed to remove any GPS related issues. However, some companies are still insisting on asynchronous operation to the exclusion of synchronous operation.

Conclusion: QUALCOMM believes that the third generation standard should be based upon synchronous operation. While there are several possible approaches for synchronous systems, the cdmaOne approach works very well and has been extensively deployed. Further adoption will maintain compatibility and minimize developmental risks, while achieving low cost.

In addition, QUALCOMM believes that Code-Division Multiplexed (CDM) pilots perform better and provide greater flexibility for cell/sector wide beams, for spot beams covering portions of cells/sectors, and for adaptive beams directed at a single mobile station, than the Time-Division-Multiplexed (TDM) pilots currently being proposed for W-CDMA. The W-CDMA proposal uses a dedicated TDM pilot per mobile station, resulting in lower system capacity and exhaustion of forward link codes utilized to support various services. The CDM approach, therefore, yields greater capacity and flexibility.

Conclusion: QUALCOMM believes that technology modifications that yield performance and cost benefits should be adopted wherever possible. Changing from CDM pilots to the W-CDMA approach of TDM pilots has thus far not demonstrated any performance or cost benefit, but to the contrary, adversely impacts capacity and flexibility. QUALCOMM advocates full public comparative testing to prove the purported advantages of this technology modification.

Principle # 4. - A variable rate speech codec should be used with efficient full, 1/2, 1/4, and 1/8-rate operation with a 20 ms frame

The variable rate vocoding scheme has been a key feature of CDMA, proven to improve system capacity and performance. This approach allows for seamless source control, which adapts the information rate of the source and efficiently uses different rates for different speech signal frames. The flexibility of the variable rate vocoder is demonstrated by the ability to support full rate, 1/2-rate, 1/4 rate and 1/8-rate operation, based on the short term phonetic character of the speech signal and on network conditions. Variable rate codecs allow signaling information to be efficiently multiplexed onto the traffic channel by reducing the codec's encoding rate to 1/2, thus incurring minimal voice quality degradation for that signaling frame. The variable rate codecs can be switched automatically to lower rate modes permitting an easy extension in range and capacity. This approach also utilizes seamless channel control of the encoding rate that allows the encoder to be scaled back to increase system capacity. Variable rate encoding has been shown to be excellent for voice storage and for packetized communication systems as well as for CDMA allowing for seamless wireless/wireline network integration.

W-CDMA is expected to use the Adaptive Multi-Rate (AMR) codec, which uses a degenerate and less effective method than true variable rate vocoding. The AMR transmission rates can be adapted to the channel and source conditions by using signaling, a far slower and cruder method of control. In contrast, the true variable rate codec can adapt its rate on a frame-by-frame basis without the need for signaling while incorporating

the advantages of seamless channel control. This flexibility of variable rate vocoding permits the rate to be instantaneously lowered when the source contains greater redundancy, increasing capacity. Furthermore, the mobile station using variable rate vocoding can autonomously reduce its transmission rate to increase range when at the edge of coverage (such as when inside a building).

Conclusion: Variable rate vocoding schemes have been well tested in cdmaOne systems and can support the needs for the next generation systems. cdmaOne systems support multiple variable rate vocoders today, permitting flexible introduction of new improvements. QUALCOMM believes that variable rate vocoding should be a key feature/criterion for the selection of third generation technology. However, QUALCOMM supports the standardization of a variety of speech codecs that utilize this beneficial method.

The cdma2000 proposal is based on a 20 millisecond (ms) frame length parameter. QUALCOMM has significant field experience with CDMA systems and has compared the relative performance of utilizing 20 ms frames against 10 ms frames, as proposed in W-CDMA. Shorter frame lengths permit somewhat shorter end-to-end delays in the system. However, in such comparisons, users cannot perceive the reduced delays, which are still on the order of 50-70ms. On the other hand, frame lengths of 20 ms are clearly more efficient in terms of overhead, and support higher system capacity, compared to the use of the smaller frame lengths.

Principle # 5. The reverse link waveform should have low energy in the audio band due to amplitude modulation and should support enhanced-range low-rate phones.

QUALCOMM believes interference with hearing aids and other devices must be minimized. To minimize interference, the radio frequency (RF) waveform must have low-energy in the modulation components, which are in the audio band. In general, CDMA systems permit the design of air interfaces that minimize the interference into the audio band.

Conclusion: Although QUALCOMM believes that this issue has been addressed in the W-CDMA proposal, the Company stresses the importance of this consideration as future modifications are discussed.

Summary:

This white paper is intended to clarify QUALCOMM's position on the five technical principles that were communicated to some of the world's key standards bodies. As part of the process, QUALCOMM also looks forward and expects to converge the W-CDMA and cdma2000 proposals in other areas to achieve a high quality, cost effective third generation system to meet the needs of global wireless users in the 21st Century. QUALCOMM recognizes that many companies are actively working on these standards and that many valuable innovations are being introduced and should in many cases be included in the standard, after proper study and test. Intentional introduction of a competitive disadvantage must not be one of the criteria for acceptance.

QUALCOMM has an extensive CDMA patent portfolio with over 130 CDMA patents issued and approximately 400 patent applications pending in the United States, Europe, Japan, Korea, China and elsewhere around the world. Prior to the adoption of the cdmaOne standard, QUALCOMM committed to license its essential patents for such standard on reasonable terms and conditions free from unfair discrimination. QUALCOMM has made good on its commitment as evidenced by the fact that QUALCOMM has licensed its essential patents for use in cdmaOne applications to more than 55 companies including nearly every major telecommunications manufacturer in North America, Europe and Asia.

QUALCOMM believes it has essential Intellectual Property Rights (IPR) for W-CDMA, and it intends to license these patents on reasonable terms and conditions free from unfair discrimination for a single converged IMT-2000 standard, or, if not achieved, only for cdma2000. In addition, QUALCOMM has extended or is preparing to extend these bilateral agreements, and the Company intends to review its royalty rates within the context of the market size that will be achieved by a single converged standard.

QUALCOMM has no intention of generally licensing its essential patent portfolio for any IMT-2000 standard (such as W-CDMA) that is purposefully made incompatible with cdmaOne and ANSI-41 without providing a material benefit to the industry.

Headquartered in San Diego, QUALCOMM (NASDAQ: QCOM) develops, manufactures, markets, licenses and operates advanced communications systems and products based on its proprietary digital wireless technologies. The Company's primary

product areas are the OmniTRACS® system (a geostationary satellite-based, mobile communications system providing two-way data and position reporting services), CDMA wireless communications systems and products and, in conjunction with others, the development of the Globalstar™ low-earth-orbit (LEO) satellite communications system. Other Company products include the Eudora Pro® electronic mail software, ASIC products and communication equipment and systems for government and commercial customers worldwide. For more information on QUALCOMM products and technologies, please visit the Company's web site at <http://www.qualcomm.com>.