

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In Re Application of: LANDE, Mark

Group Art Unit:

Serial No.

Examiner:

Filed: HEREIN

Atty. Dkt. No: 20050089-US

For: COMBINATIONAL HYBRID TURBO-MUD

42716

To: Commissioner for Patents
PO Box 1450
Alexandria, VA 22313-1450

Fm:

Commissioner:

LETTER OF TRANSMITTAL

Submitted herewith is a application for United States patent consisting of, 4 pages
Patent Application Data Sheet, 48 pages of specification and claims, 7 sheets of
drawings, 1 page of declaration and power of attorney.

- ☐ (37 CFR 1.9(f) & 1.27(c)) Small Entity status applies.
- ☐ (35 U.S.C. 122(b)(2)(B)(i)) PTO form PTO/SB/35 re: Publication enclosed
- ☒ (37 CFR 1.84(J)) – Applicant requests FIG. 2 for inclusion on the front page of the
patent application publication and patent.
- ☐ PCT application being filed concurrently

This application is related to U.S. Application No. 10/626,146, filed 07/24/2003,
titled “Hybrid Turbo-MUD for Overloaded Multiple Access Systems” which is herein
incorporated in its entirety by reference for all purposes.

Portions of the present invention have been made in conjunction with Government
funding under DARPA Contract No. HR0011-05-C-0064 and there may be certain rights to the
Government.

Fee calculation table:

Fee calculation is based on 3 independent and 20 total claims

☒ Basic filing fee – Utility - \$300.00	\$300.00
☒ Search fee – Utility - \$500.00	\$500.00
☒ Examination fee – Utility - \$200.00	\$200.00
☐ Independent claims in excess of three - ___x \$200.00 ea.	
☐ Claims in excess of twenty - ___x \$50.00 ea.	
TOTAL DUE:	<u>\$1000.00</u>

DEPOSIT ACCOUNT **190130** AUTHORIZATION – The Office is hereby authorized to charge the required fee, and any deficiency or credit any overpayment in the fees to the above deposit account, owned by BAE SYSTEMS Information and Electronic Systems Integration Inc. an authorized signator for which is Kevin M. Perkins, V.P. & Company Counsel, and for whom the undersigned are authorized agents.

Respectfully submitted,

/Scott J. Asmus, Reg. No. 42,269/

Cus. No. 42716
Maine & Asmus
PO Box 3445
Nashua, NH 03061-3445
Tel. No. (603) 886-6100, Fax. No. (603) 886-4796
Patents@maineandasmus.com

Scott J. Asmus, Reg. No. 42,269
Andrew P. Cernota, Reg. No. 52,711
Kristina M. Grasso, Reg. No. 39,205
Attorneys/Agents for Applicant

Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it contains a valid OMB control number.

Application Data Sheet 37 CFR 1.76		Attorney Docket Number	20050089-US
		Application Number	
Title of Invention	COMBINATIONAL HYBRID TURBO-MUD		
The application data sheet is part of the provisional or nonprovisional application for which it is being submitted. The following form contains the bibliographic data arranged in a format specified by the United States Patent and Trademark Office as outlined in 37 CFR 1.76. This document may be completed electronically and submitted to the Office in electronic format using the Electronic Filing System (EFS) or the document may be printed and included in a paper filed application.			

Secrecy Order 37 CFR 5.2

☐	Portions or all of the application associated with this Application Data Sheet may fall under a Secrecy Order pursuant to 37 CFR 5.2 (Paper filers only. Applications that fall under Secrecy Order may not be filed electronically.)
--------------------------	---

Applicant Information:

Applicant 1					Remove	
Applicant Authority		☒ Inventor		☐ Legal Representative under 35 U.S.C. 117		☐ Party of Interest under 35 U.S.C. 118
Prefix	Given Name	Middle Name	Family Name		Suffix	
	Mark		Lande			
Residence Information (Select One)		☒ US Residency ☐ Non US Residency ☐ Active US Military Service				
City	Nashua	State/Province	NH	Country of Residence i	US	
Citizenship under 37 CFR 1.41(b) i		US				
Mailing Address of Applicant:						
Address 1		49 Ledgewood Hills Drive				
Address 2						
City	Nashua	State/Province	NH			
Postal Code	03062	Country i	US			
All Inventors Must Be Listed - Additional Inventor Information blocks may be generated within this form by selecting the Add button.						
Add						

Correspondence Information:

Enter either Customer Number or complete the Correspondence Information section below. For further information see 37 CFR 1.33(a).		
☐ An Address is being provided for the correspondence information of this application.		
Customer Number	42716	
Email Address	patents@maineandasmus.com	Add Email Remove Email

Application Information:

Title of the Invention	COMBINATIONAL HYBRID TURBO-MUD		
Attorney Docket Number	20050089-US	Small Entity Status Claimed	☐
Application Type	Nonprovisional		
Subject Matter	Utility		
Suggested Class (if any)		Sub Class (if any)	
Suggested Technology Center (if any)			
Total Number of Drawing Sheets (if any)	7	Suggested Figure for Publication (if any)	2

Application Data Sheet 37 CFR 1.76		Attorney Docket Number	20050089-US
		Application Number	
Title of Invention	COMBINATIONAL HYBRID TURBO-MUD		
Publication Information:			
☐ Request Early Publication (Fee required at time of Request 37 CFR 1.219)			
☐ Request Not to Publish. I hereby request that the attached application not be published under 35 U.S.C. 122(b) and certify that the invention disclosed in the attached application has not been and will not be the subject of an application filed in another country, or under a multilateral agreement, that requires publication at eighteen months after filing.			

Representative Information:

Representative information should be provided for all practitioners having a power of attorney in the application. Providing this information in the Application Data Sheet does not constitute a power of attorney in the application (see 37 CFR 1.32). Enter either Customer Number or complete the Representative Name section below. If both sections are completed the Customer Number will be used for the Representative Information during processing.			
Please Select One:	☒ Customer Number	☐ US Patent Practitioner	☐ US Representative (37 CFR 11.9)
Customer Number	42716		

Domestic Priority Information:

This section allows for the applicant to claim benefit under 35 U.S.C. 119(e), 120, 121, or 365(c). Providing this information in the application data sheet constitutes the specific reference required by 35 U.S.C. 119(e) or 120, and 37 CFR 1.78(a)(2) or CFR 1.78(a)(4), and need not otherwise be made part of the specification.			
Prior Application Status		Remove	
Application Number	Continuity Type	Prior Application Number	Filing Date (YYYY-MM-DD)
Additional Domestic Priority Data may be generated within this form by selecting the Add button.			Add

Foreign Priority Information:

This section allows for the applicant to claim benefit of foreign priority and to identify any prior foreign application for which priority is not claimed. Providing this information in the application data sheet constitutes the claim for priority as required by 35 U.S.C. 119(b) and 37 CFR 1.55(a).			
			Remove
Application Number	Country ⁱ	Parent Filing Date (YYYY-MM-DD)	Priority Claimed
			☒ Yes ☐ No
Additional Foreign Priority Data may be generated within this form by selecting the Add button.			Add

Assignee Information:

Providing this information in the application data sheet does not substitute for compliance with any requirement of part 3 of Title 37 of the CFR to have an assignment recorded in the Office.	
Assignee 1	Remove
If the Assignee is an Organization check here. ☒	

Application Data Sheet 37 CFR 1.76		Attorney Docket Number		20050089-US	
		Application Number			
Title of Invention		COMBINATIONAL HYBRID TURBO-MUD			
Organization Name		BAE SYSTEMS INFORMATION AND ELECTRONIC SYSTEMS INTEGRATION INC.			
Mailing Address Information:					
Address 1		65 Spit Brook Road			
Address 2					
City		Nashua	State/Province		NH
Country ⁱ	US	Postal Code		03061	
Phone Number		Fax Number			
Email Address					
Additional Assignee Data may be generated within this form by selecting the Add button. Add 					

Signature:

A signature of the applicant or representative is required in accordance with 37 CFR 1.33 and 10.18. Please see 37 CFR 1.4(d) for the form of the signature.					
Signature		/Scott J. Asmus, Reg. No. 42,269/		Date (YYYY-MM-DD)	
				2006-09-15	
First Name	Scott	Last Name	Asmus	Registration Number	42,269

This collection of information is required by 37 CFR 1.76. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 23 minutes to complete, including gathering, preparing, and submitting the completed application data sheet form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

Privacy Act Statement

The Privacy Act of 1974 (P.L. 93-579) requires that you be given certain information in connection with your submission of the attached form related to a patent application or patent. Accordingly, pursuant to the requirements of the Act, please be advised that: (1) the general authority for the collection of this information is 35 U.S.C. 2(b)(2); (2) furnishing of the information solicited is voluntary; and (3) the principal purpose for which the information is used by the U.S. Patent and Trademark Office is to process and/or examine your submission related to a patent application or patent. If you do not furnish the requested information, the U.S. Patent and Trademark Office may not be able to process and/or examine your submission, which may result in termination of proceedings or abandonment of the application or expiration of the patent.

The information provided by you in this form will be subject to the following routine uses:

1. The information on this form will be treated confidentially to the extent allowed under the Freedom of Information Act (5 U.S.C. 552) and the Privacy Act (5 U.S.C. 552a). Records from this system of records may be disclosed to the Department of Justice to determine whether the Freedom of Information Act requires disclosure of these records.
2. A record from this system of records may be disclosed, as a routine use, in the course of presenting evidence to a court, magistrate, or administrative tribunal, including disclosures to opposing counsel in the course of settlement negotiations.
3. A record in this system of records may be disclosed, as a routine use, to a Member of Congress submitting a request involving an individual, to whom the record pertains, when the individual has requested assistance from the Member with respect to the subject matter of the record.
4. A record in this system of records may be disclosed, as a routine use, to a contractor of the Agency having need for the information in order to perform a contract. Recipients of information shall be required to comply with the requirements of the Privacy Act of 1974, as amended, pursuant to 5 U.S.C. 552a(m).
5. A record related to an International Application filed under the Patent Cooperation Treaty in this system of records may be disclosed, as a routine use, to the International Bureau of the World Intellectual Property Organization, pursuant to the Patent Cooperation Treaty.
6. A record in this system of records may be disclosed, as a routine use, to another federal agency for purposes of National Security review (35 U.S.C. 181) and for review pursuant to the Atomic Energy Act (42 U.S.C. 218(c)).
7. A record from this system of records may be disclosed, as a routine use, to the Administrator, General Services, or his/her designee, during an inspection of records conducted by GSA as part of that agency's responsibility to recommend improvements in records management practices and programs, under authority of 44 U.S.C. 2904 and 2906. Such disclosure shall be made in accordance with the GSA regulations governing inspection of records for this purpose, and any other relevant (i.e., GSA or Commerce) directive. Such disclosure shall not be used to make determinations about individuals.
8. A record from this system of records may be disclosed, as a routine use, to the public after either publication of the application pursuant to 35 U.S.C. 122(b) or issuance of a patent pursuant to 35 U.S.C. 151. Further, a record may be disclosed, subject to the limitations of 37 CFR 1.14, as a routine use, to the public if the record was filed in an application which became abandoned or in which the proceedings were terminated and which application is referenced by either a published application, an application open to public inspections or an issued patent.
9. A record from this system of records may be disclosed, as a routine use, to a Federal, State, or local law enforcement agency, if the USPTO becomes aware of a violation or potential violation of law or regulation.

COMBINATIONAL HYBRID TURBO-MUD

Inventor:
Mark Lande

CROSS REFERENCE TO RELATED APPLICATIONS

[0001] This application is related to U.S. Application No. 10/626,146, filed 07/24/2003, titled "Hybrid Turbo-MUD for Overloaded Multiple Access Systems" which is herein incorporated in its entirety by reference for all purposes.

STATEMENT OF GOVERNMENT INTEREST

[0002] Portions of the present invention have been made in conjunction with Government funding under DARPA Contract No. HR0011-05-C-0064 and there may be certain rights to the Government.

FIELD OF THE INVENTION

[0003] This present invention relates to advanced receiver techniques for processing signals, and more particularly to multi-user detection (MUD) for processing multiple users' signals that interfere with one another.

BACKGROUND OF THE INVENTION

[0004] Increased usage and higher content demands have rapidly changed the wireless landscape. The data demands require greater efficiency and the ability to process overloaded environments and extracting more information signals within a limited bandwidth. The multiple-access receiver processing procedures allow for multiple users to access the same communications medium to transmit or receive information. In addition to the problems associated with multiple users in a given bandwidth, an

additional problem is the inability to process the data in the receivers in real time. Advanced receiver processing techniques cover several areas, namely interference suppression (also called Multi-User Detection or MUD), multipath combining and space-time processing, equalization, and channel estimation. These various techniques can be mixed and matched depending upon the circumstances. Proper signal processing of transmitter and receiver yield a far greater potential than current systems.

[0005] For example, a base station that processes a number of cellular devices has to receive and transmit data within a certain frequency range. The ability to extract the correct data from a given user is a difficult task when the effects of interference and multipaths are considered. The problem is further complicated when the number of users exceeds the number of dimensions (e.g. time slots, frequency slots, polarizations, etc), resulting in an overloaded condition.

[0006] In the past, multiple access (MA) communication systems generally utilized Frequency Division Multiple Access (FDMA) and Time Division Multiple Access (TDMA) methods to achieve channel access. FDMA refers to the parsing up of an allocated band for a communication system wherein a single user's signal transmission power is concentrated into a single narrower radio frequency band. Interference from adjacent channels is limited by the use of band pass filters for each channel being assigned a different frequency system, total capacity is limited by the available frequency slots and by physical limitations imposed by frequency reuse.

[0007] In TDMA systems, a channel consists of a time slot or frame in a periodic train of time intervals over the same frequency, with a given signal's energy confined to one of these time slots. Adjacent channel interference is limited by the use of a time gate or other synchronization element that only passes signal energy received at the proper time. The system capacity is limited by the available time slots (within a given

frequency band) as well as by physical limitations imposed by frequency reuse, as each channel is assigned a different time slot within a particular frequency band.

[0008] One of the goals of FDMA and TDMA systems is to try and prevent two potentially interfering signals from occupying the same frequency at the same time, namely co-channel interference. In contrast, Code Division Multiple Access (CDMA) techniques allow signals to overlap in both time and frequency. CDMA signals share the same frequency spectrum at the same time, hence, the CDMA signals appear to overlap one another. The scrambled signal format of CDMA reduces cross talk between interfering transmitters.

[0009] In a CDMA system, each signal is transmitted using spread spectrum techniques. The transmitted informational data stream is impressed upon a much higher rate data stream termed a signature sequence. The bit stream of the signature sequence data is typically binary, and can be generated using a pseudo-noise (PN) process that appears random, but can be replicated by an authorized receiver. The informational data stream and the high bit rate signature sequence stream are combined by multiplying the two bit streams together, assuming the binary values of the two bit streams are represented by +1 or -1. This combination of the higher bit rate signal with the lower bit rate data stream is called spreading the informational data stream signal. Each informational data stream or channel is allocated a unique signature sequence.

[0010] In operation, a stream of spread information signature signals are modulated by weights corresponding to the information that is to be transmitted. Some modulation examples include binary phase shift keying (BPSK) and quadrature phase shift keying (QPSK). If several transmitters modulate their data onto the signature waveform and modulate again with the carrier tone, a radio frequency (RF) signal comprised of a continuous stream of information modulated signature pulses will be present at the

receiver, one corresponding to each transmitter. The transmitted signals are jointly received as a composite signal at the receiver. Each of the spread signals overlaps all of the other spread signals in time and frequency. Moreover, environmental noise as well as receiver electronic noise is also present in the measured received signal. A conventional CDMA receiver correlates the composite noisy signal with one of the unique signature sequences, and the corresponding information signal is isolated and despread while the other signals appear as only small additions to the noise floor.

[0011] A signature sequence is often used to represent one bit of information. Receiving the transmitted sequence or its complement indicates whether the information bit is a +1 or -1, sometimes denoted "0" or "1". The signature sequence usually comprises N pulses, and each pulse is called a "chip". The entire N-chip sequence, or its complement, depending on the information bit to be conveyed, is referred to as a transmitted symbol.

[0012] The receiver correlates the received signal with the complex conjugate of the known signature sequence to produce a correlation value. When a 'large' positive correlation results, a "0" is detected, and when a 'large' negative correlation results, a "1" is detected.

[0013] It should be understood that the information bits could also be coded bits (also referred to as channel bits or symbols), where the code is a block or convolutional code. Also, the signature sequence can be much longer than a single transmitted symbol, in which case a subsequence of the signature sequence is used to spread the information bit.

[0014] The present systems typically do not properly account for the real world mobile communication signals and the signal degradation such as interference and multipath problems. The system use assumptions that all other interferers and multipaths are additive white Gaussian noise, which is not accurate for co-channel interference and multipaths.

[0015] Multipath dispersion occurs when a signal proceeds to the receiver along not one but many paths so that the receiver encounters echoes having different and randomly varying delays and amplitudes. The receiver receives a composite signal of multiple versions of the transmitted symbol that have propagated along different paths, called rays, having different relative time. Each distinguishable ray has a certain relative time of arrival, a certain amplitude and phase, and as a result, the correlator outputs several smaller spikes. RAKE receivers are well known and attempt to 'rake' together all the contributions to detect the transmitted symbol and recover the information bit.

[0016] Conventional RAKE receivers provide satisfactory performance for operation in the presence of multipath under ideal conditions however the signature sequence must be uncorrelated with time shifted versions of itself as well as various shifted versions of the signature sequences of the other CDMA signals. Co-channel interference refers to signals received from other users either directly or reflected. If one received signal corresponding to the signature sequence of interest has a non-negligible cross correlation with the received signal originating from another transmitter (a co-channel interferer), then the value measured at the receiver, e.g. the correlation value for the signal of interest, is corrupted. In other words, the correlation computed at the receiver that would be used to decode a particular signal of interest is overwhelmed by an interfering signal; this is referred to as the near-far problem. The interference caused by an echo of one transmitted symbol overlapping with the next transmitted symbol might also be non-negligible. If this is the case, the transmitted symbols interfere with past and future transmitted symbols. This is commonly referred to as intersymbol interference (ISI). In actuality, performance is degraded both by co-channel interference and ISI.

[0017] There has been much research to address signal interference with known multipath time dispersion. This is termed joint demodulation with no multipath and is further described in S. Verdu, "Minimum Probability of

Error For Asynchronous Gaussian Multiple-Access Channels," IEEE Trans. Info. Theory, Vol. IT-32, pp. 85-96, R. Lupas and S. Verdu, "Linear multiuser detectors for synchronous code-division multiple-access channels," IEEE Trans. Inform. Theory, Vol. 35, pp. 123-136, Jan. 1989; and R. Lupas and S. Verdu, "Near-far resistance of multiuser detectors in asynchronous channels," IEEE Trans. Commun., Vol. 38, pp. 496-508, Apr. 1990.

[0018] There are a host of approaches for jointly demodulating any set of interfering digitally modulated signals, including multiple digitally modulated signals. Maximum Likelihood Sequence Estimation determines the most likely set of transmitted information bits for a plurality of digital signals without multipath time dispersion. The maximum likelihood joint demodulator is capable, in theory, of accommodating the largest number of interfering signals, but has a prohibitive computational complexity that makes it unrealizable in practice. The decorrelation receiver is another, less computationally complex receiver processing approach that zeroes out or decorrelates the different signals so that they no longer interfere with one another. The decorrelator as well as virtually every other lower complexity joint demodulator, is not capable of operation when the number of signals is over a set threshold which falls significantly short of the theoretical maximum.

[0019] In a real world multi-user system, there are a number of independent users simultaneously transmitting signals. These transmissions have the real-time problems of multi-path and co-channel interference, fading, and dispersion that affect the received signals. As described in the prior art, multiple user systems communicate on the same frequency and at the same time by utilizing parameter and channel estimates that are processed by a multi-user detector. The output of the optimal multi-user detector operating within the multiuser capacity limits of the channel is an accurate estimation as to the individual bits for an individual user.

[0020] Moreover, in an article by Paul D. Alexander, Mark C. Reed, John A. Asenstorfer and Christian B. Schlegel in IEEE Transactions on Communications, vol. 47, number 7, July 1999, entitled "Iterative Multi-User Interference Reduction: Turbo CDMA," a system is described in which multiple users can transmit coded information on the same frequency at the same time, with the multi-user detection system separating the scrambled result into interference-free voice or data streams.

[0021] Low complexity multiuser detector have been contemplated that use linear multiuser detectors to achieve optimal near-far resistance. (Near-Far Resistance of Multiuser Detectors for Coherent Multiuser Communications, R. Lupas, S. Verdu, IEEE Trans. Commun. Vol. 38, no. 4, pp 495-508, April 1990). While providing certain advantages, the performance has not been demonstrably improved. Varanasi and Aazhang proposed a multistage technique as described in the article Near-Optimum Detection in Synchronous Code-Division Multiple Access Systems, IEEE Trans. Commun., Vol. 39, No. 5, May 1991.

[0022] Decorrelating decision feedback detectors (DDFD) have been described by A. Duel-Hallen in Decorrelating Decision-Feedback Multiuser Detector for Synchronous Code-division Multiple Access Channel, IEEE Trans. Commun., Vol. 41, pp 285-290, Feb. 1993. Wei and Schlegel proposed soft-decision feedback to suppress error propagation of the DDFD in Synchronous DS-SSMA with Improved Decorrelating Decision-Feedback Multiuser Detection, IEEE Trans. Veh. Technol., Vol. 43, pp 767-772, Aug. 1994. Tree-type maximum-likelihood sequence detectors were also proposed for multiuser systems as were breadth-first algorithms and sequential detection including using the M-algorithm tree-search scheme with a whitened matched filter (WMF).

[0023] However, one of the primary disadvantages of some of the prior implementations is the inability to accommodate overloaded conditions. The DDFD techniques are limited in that they are incapable of working in supersaturated environments. Generally, only the MMSE-based or tree

based decision feedback detector can work in a supersaturated environment, however it is too aggressive with hypothesis testing to produce accurate results.

[0024] Multi-user detection (MUD) refers to the detection of data in non-orthogonal channels. MUD processing increases the number of bits available per chip or signaling dimension for systems having interference limited systems. A MUD receiver jointly demodulates co-channel interfering digital signals.

[0025] Optimal MUD based on the maximum likelihood sequence estimator operates by comparing the received signal with the entire number of possibilities that could have resulted, one for each bit or symbol epoch. The number of possible measured levels for the received signal is exponentially related to the number of users and the duration of the ISI. Hence, the optimal processing is a computationally complex and it is not possible to accomplish in a real-time environment. Thus for those multi-user detectors that examine the entire space, real-time operation is often elusive.

[0026] In general, optimal MUD units function by examining a number of possibilities for each bit. However, for multi-user detectors that examine a larger capacity of signal, the computations are complex and time-consuming, thus making real-time operation impossible. Numerous attempts at reliable pruning of the optimal MUD decision process or the use of linear approximation to replace the optimal MUD have still not produced a workable solution for the real world environment.

[0027] There are various multiuser detectors in the prior art, including optimal or maximum likelihood MUD, maximum likelihood sequence estimator for multiple interfering users, successive interference cancellation, TurboMUD or iterative MUD, and various linear algebra based multi-user detectors such as all of those detailed in the well-known text "Multiuser Detection" by Sergio Verdu. In basic terms, turbodecoding refers to breaking a large processing process into smaller pieces and

performing iterative processing on the smaller pieces until the larger processing is completed. This basic principle was applied to the MUD.

[0028] There are several suboptimal multiuser detectors that are less computationally complex and known in the art. One example of suboptimal detectors, called linear detectors, includes decorrelators, minimum mean square error or MMSE detectors, and zero-forcing block linear equalizers. But, certain linear based MUD (non-iterative) and successive interference cancellation fails for cases of overloaded multiple access systems. One example of overloading is where the number of simultaneous users is doubled or tripled relative to existing state of the art. Even for underloaded multiple access systems, the performance of non-iterative MUD and successive interference cancellation degrades significantly as the number of users increases, while the computational complexity of the optimal MUD increases significantly as the number of users increases. The computing problems are so extreme that even the most expensive hardware unbound by size and weight can not keep up with this overwhelming complex processing requirement of optimal MUD. Moreover, an unreasonable delay would be required to decode each bit or symbol rendering such a system useless in practice.

[0029] Reduced complexity approaches based on tree-pruning help to some extent to eliminate the improper bit combination from consideration where, ideally, such a procedure should prune out many 'bad' paths in the decision tree but maintain the proper path. Thus, the entire tree does not need to be traversed to make the final decision.

[0030] The M-algorithm is a pruning process that limits the number of hypotheses extended to each stage to a fixed tree width and prunes based on ranking metrics for all hypotheses and retaining only the M most likely hypotheses. The T-algorithm prunes hypotheses by comparing the metrics representing all active hypotheses to a threshold based on the metric corresponding to the most-likely candidate. Performance of M-algorithm based MUD degrades as the parameter M is decreased, but M governs the

number of computations required. Similar effects are seen for other tree-pruning based MUD (T- algorithm, etc). To combat improper pruning, basic tree-pruning must ensure that M is “large enough”, and therefore still encounters increased complexity for acceptable performance levels when the number of interfering signals and/or ISI lengths are moderate to large.

[0031] As an illustration of the M-algorithm as a tree-pruning algorithm, consider a tree made up of nodes and branches. Each branch has a weight or metric, and a complete path is sequences of nodes connected by branches between the root of the tree and its branches. When applied as a short cut to the optimal MUD, each branch weight is a function of the signature signal of a certain transmitter, the possible bit or symbol value associated with that transmitter at that point in time, and the actual received signal which includes all the signals from all the interfering transmissions. The weight of each path is the sum of the branch metrics in a complete path. The goal of a tree searching algorithm is to try to find the complete path through a tree with the lowest metric. With the present invention the metrics of multiple complete paths are not calculated. Rather, the metrics of individual branches in a tree are calculated in the process of locating one complete path through the tree and thereby defines one unknown characteristic of each of the co-channel, interfering signals needed to decode the signals.

[0032] A MUD algorithm within the TurboMUD system determines discrete estimates of the transmitted channel symbols, with the estimates then provided to a bank of single-user decoders (one decoder for each user) to recover the input bit streams of all transmitted signals. Two general types of multi-user detectors within the TurboMUD system are possible, namely those that provide hard outputs, which are discrete values, and those that provide soft outputs, which indicate both the discrete estimate and the probability that the estimate is correct.

[0033] However, single-user decoders operating on hard values, or discrete integers, have unacceptable error rates when there is a large

amount of interference or noise in the received signal. The reason is that discrete integers do not provide adequate confidence values on which the single-user decoder can operate. These decoders operate better on so-called soft inputs in which confidence values can range from -1 to 1, such as for instance .75 as opposed to being either -1 or +1. To provide soft values that can then be utilized by a single-user decoder, the multi-user detector chosen for the TurboMUD can generate these soft values. The invention described below will work with soft output or a hard output MUDs, or a combination of the two.

[0034] In general, soft or hard output versions of the optimum maximum likelihood multi-user detector (Verdu, Multiuser Detection, Cambridge University Press, 1998) or an M algorithm (as described, for instance, in Schlegel, Trellis Coding, IEEE Press, 1997) with a moderate to high value of M causes the Turbo MUD to require too many computations to keep up with real time transmissions. Using a fast, but inferior, multiuser detection scheme such as a linear-based detector or those detailed in the text "Multiuser Detection" by Sergio Verdu causes poor quality output when there are many or strongly correlated interferers or users.

[0035] Moreover, when dealing with hand-held communications units such as wireless handsets, the amount of processing within the device is limited, directly limiting the amount of computational complexity that is allowed. In order to provide real-time performance both at a cell site and the handset, it therefore becomes important to be able to reduce the amount of computational complexity and processing time so as to achieve real-time performance.

[0036] The growing demand for processing more data and in a smaller bandwidth raises the need to optimize performance. What is needed is an efficient signal processing system and processing to improve the quality and spectral efficiency of wireless communications and better techniques for sharing the limited bandwidth among different high capacity users

SUMMARY OF THE INVENTION

[0037] The invention is devised in the light of the problems of the prior references described herein, and a general object is to provide a more efficient MUD processing that still provides a satisfactory bit error rate (BER).

[0038] One embodiment of the invention is a hybrid Multi-User Detector System for processing received signals, having a parameter estimator coupled to the received signals providing received data information. There is a multi-user detector decision unit coupled to the parameter estimator and the received signals with at least two multi-user detectors coupled to the parameter estimator and the multi-user detector decision unit. The multi-user detector decision unit uses decision criteria to determine a selected multi-user detector, and the selected multi-user detector outputs a plurality of information streams, one stream corresponding to each of the received signals. There are a bank of decoders, such as low complexity decoders and high complexity decoders, coupled to the plurality of information streams, wherein the decoders output a plurality of improved information streams.

[0039] In a turboMUD embodiment, the plurality of improved information streams are fed back to the multi-user detector decision unit until a final condition is reached and the bank of decoders output a final data stream.

[0040] According to one embodiment, the design criteria is based upon at least one threshold, where the threshold is selected from at least one of the group consisting of: number of symbols, correlation matrix between users, expected bit error rate, eigendecomposition of correlation matrix, signal to interference plus noise ratio, and expected SINR. In addition, the threshold can be dynamically changeable such that at each iteration the threshold can be changed. The threshold can also be changed depending

upon which multi-user is selected. There can also be multiple thresholds for the various multi-user detectors.

[0041] An additional embodiment includes wherein the at least two multiuser detectors are selected from the group consisting of: M-algorithm, T-algorithm, FANO, reduced state Viterbi, Maximum Likelihood, matched filter, mean squared error (MMSE), decorrelator, and combinations thereof.

[0042] A further feature includes an interleaver unit and a deinterleaver unit coupled between the bank of decoders and the multi-user detectors. There can also be a filter unit coupled to the received signals, wherein the filter unit is coupled to the multi-user detector decision unit. In addition, there can be a hard decision unit coupled to the bank of decoders and producing the final data stream. In one variation the final condition is determined by one of a fixed number of iterations and an allowable performance level.

[0043] One embodiment of the invention is a hybrid receiver for processing a plurality of received signals, the receiver comprising a parameter estimation unit coupled to the received signals, wherein the parameter estimation unit extracts received signal information. There is a multi-user detector decision unit coupled to the parameter estimator and the received signals. A low complexity multi-user detector is switchably coupled by the multi-user detector decision unit, wherein the low complexity multi-user detector outputs a plurality of low complexity processed information streams. A high complexity multi-user detector is switchably coupled by the multi-user detector decision unit, wherein the high complexity multi-user detector outputs a plurality of high complexity processed information streams. A bank of decoders is coupled to the plurality of low complexity processed information streams and the plurality of high complexity processed information streams, wherein the decoders output a plurality of refined information streams. In one embodiment the

receiver uses the high complexity multi-user detector after first processing with the low complexity multi-user detector.

[0044] A turboMUD embodiment wherein said plurality of refined information streams are fed back to said multi-user detector decision unit for iterative processing until a final condition is reached and the bank of error correction decoders output a final plurality of symbol streams.

[0045] In one embodiment the multi-user detector decision unit makes a selection determined by design criteria based upon at least one threshold selected from at least one of the group consisting of: number of symbols, correlation matrix between users, expected bit error rate, eigendecomposition of correlation matrix, signal to interference plus noise ratio, and expected SINR.

[0046] One variation includes the hybrid receiver having a front end section coupled to the received signals and to the received signal information which filters the received signals.

[0047] A further embodiment of the invention is a method for processing signals from multiple users providing raw digitized data. The method include performing parameter estimation of the raw digitized data, grabbing a window of bits from the raw digitized data, subtracting any known bits from the window of bits, selecting a multi-user detector, computing decision tree searching path metrics from the window of bits using the multi-user detector, incrementing to a next window of bits, repeating the steps of subtracting, selecting, computing and incrementing until there are no more windows, and outputting a set of symbol estimates.

[0048] As detailed herein, the multi-user detector is selectable from the group consisting of high complexity multi-user detectors, low complexity multi-user detectors and matched filters.

[0049] One method for determining a size of the window is by using an intersymbol interference length and a cochannel interference length.

[0050] According to one embodiment the method includes checking the symbol estimates for a threshold condition. The method includes outputting a final symbol stream for each user if passing the threshold condition, and repeating the steps of subtracting, selecting, computing and incrementing if failing the threshold condition.

[0051] The features and advantages described herein are not all-inclusive and, in particular, many additional features and advantages will be apparent to one of ordinary skill in the art in view of the drawings, specification, and claims. Moreover, it should be noted that the language used in the specification has been principally selected for readability and instructional purposes, and not to limit the scope of the inventive subject matter.

BRIEF DESCRIPTION OF THE DRAWINGS

[0052] The present invention will be readily understood by the following detailed description in conjunction with the accompanying drawings, wherein like reference numerals designate like structural elements, and in which:

[0053] **Figure 1** shows a block diagrammatic presentation of a prior art conventional turbo MUD system illustrating the iterative processing that takes advantage of improvements in partial information gained with each iteration through the use of conditional probabilities for each decoded symbol of each user;

[0054] **Figure 2** is a block diagrammatic perspective according to one embodiment of a hybrid MUD that selects the MUD based on certain metrics;

[0055] **Figure 3** is a block diagrammatic perspective of a hybrid MUD in accordance with one embodiment of the present invention;

[0056] **Figure 4** is a flow chart showing processing steps according to one embodiment;

[0057] **Figure 5a** illustrates a block diagram system of the present invention in accordance with one embodiment;

[0058] **Figure 5b** illustrates a block diagram system of the present invention in accordance with another embodiment; and

[0059] **Figure 5c** illustrates a block diagram system of the present invention in accordance with a further embodiment.

DETAILED DESCRIPTION

[0060] The methods and embodiments of the Hybrid Turbo-MUD disclosed herein enable implementations of advanced receiver processing providing high quality real-time processing for multiple access systems, including overloaded conditions. The embodiments herein illustrate digital processing technique applicable to many variations and applications all within the scope of the invention.

[0061] Referring to **Figure 1**, the basic iterative MUD procedure is diagrammatically presented, and is well known from published literature such as Poor, "Turbo Multiuser Detection: An overview," IEEE 6th Int. Symp. On Spread-Spectrum Tech. And Appli., NJIT, New Jersey, Sept. 6-8, 2000 and Alexander, Reed, Asenstorfer, and Schlegel, "Iterative Multiuser Interference Reduction: Turbo CDMA," IEEE Trans. On Comms., v41, n7, July 1999. The iterative MUD is representative of the approaches used to incorporate turbo decoding methods into joint MUD/FEC (Forward Error Correction) decoding and to then reduce the complexity of the system.

[0062] It should be readily appreciated that there are two general embodiments applicable to the MUD of **Figure 1**, namely an iterative embodiment and a non-iterative embodiment. The iterative embodiment or Turbo-MUD is described herein while the non iterative MUD merely runs a single cycle through the process.

[0063] The raw input data represents data after some front end processing such as downconversion, amplification, and analog-to-digital conversion, although other forms of communication have been contemplated herein. The input signal of raw non-manipulated data at the receiver is comprised of the aggregate of many signals from many different transmitters, where each signal is assigned a signature pulse for the transmission of symbols. Traditionally, these signature pulses occupy either a specific frequency, timeslot, and/or spreading code and are referred to as occupying a specific channel from a finite set of channels. In a typical scenario, the aggregate signal is collected at the receiver, down-converted and digitized.

[0064] A parameter estimation unit **10** processes the various parameters for the received raw data, and provides certain information to the MUD **20**. The purpose of the parameter estimator **10**, is to provide the receiver information such as estimate timing offsets, signal amplitudes, carrier phases, polarizations, channel transfer functions, carrier frequency offset or Doppler frequency offset, coding rates, identification of active channels, as well as any other information required by the MUD to carry out its processing. The parameter estimation unit is known in the art, and a detailed description is available in U.S. Patent Application No. 6,947,505 entitled "System for Parameter Estimation and Tracking of Interfering Digitally Modulated Signals", which is incorporated by reference herein.

[0065] This digital input signal or raw input data is then input to the multiuser detector (MUD) **20**. The MUD processing can employ the various state of the art schemes, including M-algorithm, T-algorithm, Fano-algorithm and other tree-pruned approaches known to those in the art. The MUD processing can also employ a lower complexity linear MUD with a higher expected BER. MUD systems generally require some user signal parameters in order to establish accurate decision trees for processing.

[0066] In an optimal case, the MUD detector **20** can be a full-complexity maximum a posteriori (MAP) detector. Suboptimal reduced complexity MAP-based approaches are also known in the relevant art. The data streams from the MUD **20** are passed to a bank of error correction decoders unit **40**. In the non-iterative MUD, the raw data is processed by a MUD algorithm which outputs an estimate of each transmitted symbol corresponding to each active user/channel. These stream of symbols, likely corrupted by errors, are passed to the bank of error correction decoders unit **40**, one for each user/channel, which is capable of outputting either a corrected symbol stream for each user (hard decision decoder) or a real number corresponding to the likelihood that each symbol is some specific value (soft decision decoder). For convenience, the terms channel bits, coded bits, and symbol are deemed equivalent and may be used interchangeably.

[0067] The MUD engine **20** within the TurboMUD can be structured for hard or soft output as well as hard or soft input processing, however in order to demonstrate a working embodiment, the soft input and soft output version is addressed herein, but it is well within the scope of the present invention to utilize any combinations of the other options.

[0068] In a Turbo-MUD system, decoding and confidence information is passed between the MUD **20** and decoder components **40**. Maximum a posteriori (MAP) decoders (or approximations of MAP decoders) are well known to those in the art and are used for both the MUD and single-user (SU) decoders, so that soft output information is available if desired. The MUD **20** assumes knowledge of various parameters such as relative received timing offsets, carrier phase, frequency offsets, received amplitudes, and multipath structure for each of the interfering signals present in the received signal.

[0069] The multiuser detection unit **20** outputs a bit (or symbol) stream associated with each interfering signal present on the channel for one data

block. Deinterleavers and interleavers (not shown) are optional elements coupled between the MUD **20** and the decoders **40** that are used if the transmitted signals are interleaved, such as the CDMA format. The MUD detector **20** passes soft decisions in the form of reliability, or confidence, measures to the decoders **40**. The reliability measures are presented with one associated with each symbol of each user to the bank of decoders **40**. If the signals were transmitted with interleaving, the reliability measures from the MUD **20** are first passed through a deinterleaver (not shown) and passed on in shuffled form to the decoder **40**. Shuffling refers to processing the same values but changes the placement or presentation of the values. If interleaving was present in the transmitter, an interleaver unit performs interleaving. The time-shuffled conditional probabilities are input back to the MUD section **20**. When the transmitter employs interleaving it changes the presentation of the values but not the values themselves. For example, IS-95 is the North American Cell Phone standard that employs interleaving.

[0070] In one known variation, there is a bank of error correction decoders **40** that provide soft output or restore values associated with prior probabilities. Viterbi decoders can be used, but generally outputs hard values. The single user decoders calculate conditional probabilities, one for each decoded symbol of each user, and output them as confidence values back to the MUD **20**. Soft input soft output decoders, such as MAP or soft-output Viterbi algorithm (SOVA) decoders are examples known in the art. As the output of the decoders **40** is taken here for discussion purposes to be soft values, it should be understood that the hard decision is optional depending upon the application and the implementation requirements.

[0071] MAP decoding is known in the art and further described in C. Schlegel, Trellis Coding, IEEE Press, 1997; Robertson, Villebrun and Hoeher, "A Comparison of Optimal and Sub-Optimal MAP Decoding

Algorithms Operation in the Log Domain,” ICC95; Hagenauer, and Hoeher, “A Viterbi Algorithm with Soft-Decision Outputs and its Applications,” Globecom 89; Pottie and Taylor, “A Comparison of Reduced complexity Decoding Algorithms for Trellis Codes,” J Sel. Areas in Comm Dec 1989. The iterative turbo principle, on which Turbo MUD is based, is described by Berrou, Glavieux, and Thitimajshima, “Near Shannon Limit Error-Correcting Coding and Decoding: Turbo-Codes (1),” ICC 93; Berrou and Glavieux, “Near Optimum Error Correcting Coding and Decoding: Turbo-Codes”, Trans on Comm, Oct 1996; and Wang and Kobayashi, “Low-Complexity MAP Decoding for Turbo Codes”, Vehicular Technology Conference 2000]. Turbo MUD approaches are described in, for example, Alexander, Reed, Asenstorfer, and Schlegel, “Iterative Multiuser Interference Reduction: Turbo CDMA,” Trans on Comm, July 1999; Poor, “Turbo Multiuser Detection: An Overview,” ISSSTA 2000; and Wang and Poor, “Iterative (Turbo) Soft Interference Cancellation and Decoding for Coded CDMA”, Trans on Comm, July 1999.

[0072] For TurboMUD, soft outputs for each bit of each user from the bank of decoders **40** are fed back to the MUD **20** for each iteration. The multiuser detector **20** takes these soft inputs along with the original raw input signal to calculate an improved, less corrupted bit stream for each user. This iterative process continues until the desired quality is reached or a fixed number is reached **30**. At that point, estimates of the data sequences for all active users are output. Operation then commences for the next block of data, repeating the process described above.

[0073] The number of iterations for processing between the MUD **20** and the decoders **40** can be set to a fixed counter or by checking if there were significant changes to the data from the last iteration. Once the data is no longer being altered or reaches a certain iteration counter limit, the data from the decoder **40** can be output as final estimates of what the user sent. A fixed number of iterations can be stored as the stopping point and used

and processed by the decision block **30**. Alternatively, the information between the MUD **20** and the decoders **40** repeats in subsequent iterations until an asymptote is reached or the desired performance level is attained. A buffer can store the previous values and compare them to the latter processed values during the iterative process.

[0074] When processing is completed **30**, the soft output of the bank of error decoders **40** is passed to a hard decision unit **50** which outputs the final stream of decisions or output data stream for each interfering user for the current data block. The process is repeated for all subsequent data blocks. As described herein, this prior art TurboMUD suffers from limitations with respect to real-time processing of data in a multi-user environment due to the complexity of the MUD processing. The optimal MUD (an exhaustive search of all possible received signals given the set of known parameters and known signature pulses) must check an inordinate number of possibilities. A good alternative to the exhaustive search in the pruned tree search such as the M-algorithm, T-algorithm, or Fano sequential decoder. The problem with these, however, is that when the number of interfering users is very large, as is often the case in an overloaded environment, the computational complexity required to achieve any reasonably good bit error rate does not allow for real time operation. In other words, the time it would take to do the processing with computing resources does not allow the decoded symbols to be output at the bit rate the user's are transmitting. This causes the processor to fall farther and farther behind the transmitted information streams. There is another option for a truly low complexity MUD, however, there are associated problems with using a truly low complexity suboptimal MUD for the MUD engine. Specifically, a low complexity MUD such as a minimum mean squared error (MMSE) MUD does a very poor job decoding all the user's symbols when the interference levels or the correlations between the users are very high, as is the case in an overloaded system.

[0075] As described, there are several types of MUD that have been developed to solve the overloaded user communications scenario. While the maximum likelihood (ML) detector is optimal if the coding in the signals is not used and each user is detected symbol by symbol, running an exhaustive ML search is not computationally practical or feasible. Linear MUD detectors have been developed to setup linear decision regions which, unlike the matched filter, take all the interfering users into account when setting up the decision regions. Two examples are the decorrelator detector and the MMSE detector.

$$\begin{aligned} \text{Decorrelator} & : \hat{\mathbf{b}} = (\mathbf{S}^H \mathbf{S})^{-1} \mathbf{y} \\ \text{MMSE} & : \hat{\mathbf{b}} = \left(\mathbf{S}^H \mathbf{S} + \frac{\sigma^2}{A^2} \right)^{-1} \mathbf{y} \end{aligned}$$

where $\mathbf{y}$ is equal to the matched filter outputs.

$$\mathbf{y} = \mathbf{S}^H \mathbf{S} \mathbf{A} \mathbf{b} + \mathbf{n}$$

[0076] These detectors are computationally simple but their performance suffers when the loading is high or when the correlation structure of the users is unfavorable.

[0077] Fortunately, low complexity detectors can still detect some of the users in an overloaded environment. Users who have favorable correlation structures, or higher powers will often times be detected using a lower complexity linear MUD. This allows the user to optimize the MUD performance by implementing a hybrid MUD structure as described herein in the turbo MUD.

[0078] Referring to **Figure 2**, which shows one embodiment the present invention which incorporates a decision block to choose the MUD based on some metric. In basic terms, the hybrid MUD system of the present invention optimizes the MUD algorithms for a balance between computational complexity and performance. The turbo MUD performs successive interference cancellation in an iterative loop by combining a

detector with a decoder that feeds back symbol estimates as well as probability of error estimates for each symbol. There are some MUD systems that employ a fixed approach to the turbo MUD processing such as having a high complexity MUD on the first iteration and then lower complexity MUD processing for subsequent iterations. However, the present invention provides for selecting the MUD at each iteration, or selecting the MUD within each bit window, based on certain criteria.

[0079] A brief description according to one embodiment is as follows. The raw data input **205** is fed to the parameter estimator **210** and also to a MUD decision unit **220**. The MUD algorithms **225, 230, 235** within the turbo MUD can be structured for hard or soft output as well as hard or soft input processing, and it is well within the scope of the present invention to utilize any combinations thereof.

[0080] The raw data is processed by the MUD algorithm and outputs a soft or hard output. The soft output is an estimate of each transmitted symbol corresponding to each active user/channel. The stream of symbols, likely corrupted by errors, are passed to the bank of error correction decoders **255**, one for each user/channel, which is capable of outputting either a corrected symbol stream for each user or a real number corresponding to the likelihood that each symbol is some specific value.

[0081] The MUD **225, 230, 235** assumes knowledge of various parameters such as relative received timing offsets, carrier phase, frequency offsets, received amplitudes, and channel structure for each of the interfering signals present in the received signal. The chosen MUD **225, 230, 235** outputs, for each user, a bit (or symbol) stream or a stream of soft values corresponding to the probability that a certain bit or symbol was sent by each user. The chosen MUD **225, 230, 235** is typically coupled to the parameter estimation unit **210** for obtaining information on the received signals, especially for the highest complexity MUD **225**. An optional deinterleaver **250** is employed for transmission received in an

interleaved format, such as CDMA. These symbol streams are sent to a bank of error correcting decoders **255**, which can be optionally interleaved **265** before being passed back to the MUD decision unit **220** that selects the next MUD **225, 230, 235**.

[0082] As indicated, the MUD decision unit **220** that selects from among at least one MUD **225, 230, 235** represents one of the inventive aspects of the present invention. There are many different ways that the decision can be made. The following list and descriptions are examples of possible decision metrics and are not to be considered an inclusive list or limitation to the invention. A simple way to make the decision on which MUD to use is based on the number of symbols that are being detected in a specific MUD window. A threshold can be set for every MUD technique and when the number of symbols falls below a given MUD technique's threshold it is used for demodulation. As turbo iterations progress the thresholds can change in order to allow remaining symbols that have not been removed in the Turbo iteration to go towards more complex MUD techniques. The reason for this is that the initial low complexity MUD techniques will be able to process a certain amount of symbols, while the symbols that the low complexity MUD cannot demodulate correctly will be sent to higher complexity MUDs as the process continues. However, for this further processing the overall number of symbols has been reduced by the low complexity MUD so the complexity of the higher complexity MUD is reduced as well.

[0083] Another technique for making the decision is to look at the correlation matrix between the users and comparing each diagonal term to the sum of the off diagonal correlation terms. If the ratio for a certain number of users is greater than a certain threshold then a lower complexity MUD can be used. If the ratio is below that threshold then a higher complexity MUD can be used. If more than two types of MUD are used, then multiple thresholds can be set for each MUD.

[0084] The decision can be made by calculating the expected bit error rate (BER) of each user based on all the lower complexity MUD techniques. If any of the users have an expected BER that is acceptable, or above a threshold, for any of the lower complexity MUD techniques, then use the lowest complexity MUD possible that meets that criteria. As users are removed through the turbo iteration the expected BER of the remaining users changes. If none of the users in a specific window have an expected BER below the threshold for any of the lower complexity MUD techniques then the highest complexity MUD technique should be used.

[0085] The decision can be made by taking the eigendecomposition of the correlation matrix and looking at all the eigenvalues that are above the noise floor. If the first N eigenvalues are very close to one another and the eigenvectors associated with those eigenvalues all have the same N entries terms then use a lower complexity MUD. If there are any other regions of the eigenvalues that are basically equal and the eigenvalues have the same dominant terms or if there is any one eigenvector that has a dominant term and its eigenvector is above the noise floor then use a lower complexity MUD. If the eigenvalues and eigenvectors of the correlation matrix do not have these characteristics then use the highest complexity MUD.

[0086] The decision can be made by calculating the signal to interference plus noise ratio (SINR) for each symbol. If the SINR for any symbols is above a threshold set for a specific lower complexity MUD technique then use that technique. If none of the SINR values are above any of the lower complexity MUD thresholds then use the highest complexity MUD.

[0087] The decision can be made by calculating the expected SINR value for each symbol after filtering with one of the lower complexity MUDs. If the SINR is above a threshold set for a specific lower complexity MUD technique then use that technique. If none of the post filtering SINR values are above any of the lower complexity MUD thresholds then use the highest complexity MUD.

[0088] Inside the turbo loop, a decision is made by the MUD decision unit **220** as to which MUD decoder to use based on certain criteria. The criteria can include such aspects as computational complexity, the number of bits to detect, expected BER of each detector for all users, and correlation structure. There can be a plurality of MUD units available for selection. The MUD decision unit **220** in this example decides between lower complexity linear mud **235**, a medium complexity MUD **230** and a high complexity MUD **225**.

[0089] In a turbo MUD system, decoding and confidence information is passed between the selected MUD **225**, **230**, **235** and decoder **255**. Maximum a posteriori (MAP) decoders (or approximations of MAP decoders) can be used for both the MUD and single-user (SU) decoders, so that soft output information is available if desired.

[0090] According to one embodiment, the system achieves optimal balance by using the low complexity algorithm **235** when there are a lot of bits to decode or there are certain users which have a low probability of error with the linear detector, and by using a high complexity algorithm **225** when there are very few users to detect, or the correlation structure of the remaining users implies that a linear MUD will not be able to successfully correctly detect any of the users at a required BER.

[0091] The MUD decision unit **220** according to one embodiment detects as many users as possible with a low complexity MUD **235** such as the algorithm. The low complexity MUD **235** provides symbol estimates and probabilities of error for each symbol and decisions which are then subtracted off the signal. As the MUD progresses through the turbo loops, it reaches a point where the correlation structure of the remaining users are closer and the low complexity MUD **235** will no longer be able to satisfactorily detect the users in certain windows. At this point, the computational complexity has been reduced by the low complexity MUD **235** by stripping bits off of the received sequence. This allows the higher

complexity MUD **225** such as the ML detector or M-algorithm to perform much more efficiently on the remaining symbols.

[0092] For example, decision logic may be based on BER calculations for each of the MUDs, the correlation structure, and number of bits to decode. By way of example, the number of bits remaining to decode may be used as the decision metric. In this implementation a threshold is set and compared to the number of bits to detect in each bit window. This number varies from window to window because changing correlation structures mean that a different amount of bits might be subtracted off the sequence for each window. Also users could be turning on or off during the sequence which would change the amount of bits per window in the initial turbo iteration. If the number of bits is above the threshold, a low complexity MUD **235** is used, if the number of bits is below the threshold a higher complexity MUD **225** is used. If the number of users left to decode is equal to 1 then a very low complexity detector such as a matched filter can be used (assuming no intersymbol-interference). For each iteration through the turbo MUD, the threshold can be increased so that more users can go to the high complexity MUD **225** in the later iterations.

[0093] Referring again to **Figure 2**, in one embodiment, decoders **255** provides a soft outputs in the form of a stream of values corresponding to the probability that a certain bit or symbol was transmitted within each interfering user's signal present in the received signal. The soft data streams are passed to the chosen MUD **225**, **230**, **235** and the soft bit (or symbol) decisions are passed the optional deinterleaver **250** and then to a bank of error correction decoders **235**. The interleaver **265** and de-interleaver **250** are used with interleaved transmissions, such as CDMA. Decoders **235** outputs soft values associated with the soft inputs, one stream of outputs for each interfering user present in the received signal. If not done **260**, the time-shuffled conditional probabilities are input back to the decision unit **220** for iterative processing.

[0094] These soft outputs are passed back to the MUD decision unit **220** that selects the MUD **225, 230, 235** based upon the metrics for the remaining symbol decisions in the window. The MUD processing continues with the chosen MUD **225, 230, 235** and deinterleaved by the optional deinterleaver **250** that produces an improved stream of soft bit (or symbol) decisions that are then fed into the decoder **255** for another iteration of improvement. The information between the chosen MUD **225, 230, 235** and the decoders **255** repeats in subsequent iterations until an asymptote is reached, or the desired performance level is attained.

[0095] The number of iterations for processing in the turbo MUD loop can be set to a fixed counter or by checking if there were significant changes to the data from the last iteration. For example, once the data is no longer being altered or reaches a certain iteration counter limit, the data from the decoder **255** can be output as final estimates **270** of what the user sent.

[0096] When the desired quality of detection is reached (or a fixed number of iterations), and the processing is done **260**, the soft output of decoder **255** is passed to the hard decision unit **270** for processing the hard decisions. The final stream of bits or symbols is output **275**, one stream for each user present in the interfering signal. Operation can then commence for the next block of data, repeating the process described herein.

[0097] Interleaver **265** and de-interleaver **250** are optional elements used when interleaving is present in the transmitted communications. When the transmitter employs interleaving it changes the presentation of the values but not the values themselves. When interleaving is present in the transmitter, a transmitter interleaver unit (not shown) performs interleaving, and therefore requires the deinterleaver units **250** and interleaver units **265** on the reception end. Thus, in one embodiment, the system provides hard decisions with the MUD **225, 230, 235** and bank of

decoders **255** for a reduced multi-access interference multiuser detector and hard decision error correction decoder.

[0098] According to one embodiment of the invention, the first iteration through the MUD is performed using the lower complexity MUD **235** such as a simple matched filter. Match filters are typically used if there are very few users, but even in situations with multiple users, the match filter can strip off some users. The complexity of the MUD processing depends upon the number of users, thus stripping off even a few users by using the low complexity MUD will allow the higher complexity MUD to be faster and more efficient. Thus, higher complexity MUD **225** can be used for the highly correlated signals that require the higher complexity processing.

[0099] The higher complexity MUD **225** can use better performing algorithms such as M-algorithm, T-algorithm, FANO or reduced state Viterbi. Iterations of the Turbo-MUD with the lower complexity MUD algorithms allow the present invention to operate in real-time and with lower complexity computational processing.

[00100] In one embodiment, the low complexity MUD **235** is any low complexity soft decision input soft decision output multiuser detector known in the art. Furthermore, the turbo MUD section comprising the low-complexity MUD **235**, optional deinterleaver **250**, bank of decoders **255**, optional interleaver **265**, decision block **260**, and hard decision block **270** could be replaced with the low-complexity iterative MUD such as described in the incorporated patent applications, or the linear-based soft decision MUD known in the art and described in Chan and Wornell, 'A Class of Asymptotically Optimum Iterated-Decision Multiuser Detectors', or Wang and Poor, 'Iterative (Turbo) Soft Interference Cancellation and Decoding for Coded CDMA', IEEE Trans. on Comms, July 1999, or Moher, "An iterative multiuser decoder for near capacity communication," IEEE Trans. on Comms., v46, n7, July 1998.

[00101] For illustrative purposes, MUD can be considered as a tree pruning algorithm, wherein the tree is made up of nodes and branches. Each branch has a weight or metric, and a complete path is a sequence of nodes connected by branches between the root of the tree and its branches. The weight of each path is the sum of the branch metrics in a complete path. The goal of a tree searching algorithm is to try to find the complete path through a tree with the lowest metric.

[00102] It should be apparent to those skilled in the art that any tree pruned search such as Fano algorithm, M-algorithm, T-algorithm or reduced state Viterbi can be used as the MUD decoders in the Turbo-MUD processing. The illustration and description of the M-algorithm is not a limitation to the invention and is merely one way to do a sub-optimal search that prunes some decisions without doing every possible search combination such as the maximum likelihood (ML).

[00103] The M-algorithm, known in the art, can be used as the high complexity MUD. In certain applications, the M-algorithm uses a decision tree approach that defers decisions until more evidence is accumulated, and it is a generalization that encompasses the jointly optimal maximum likelihood detector as well as the simpler decision feedback detector. The result is a hypothesis pruning procedure that performs a decision tree search by limiting the number of hypotheses extended to the next stage of the decision tree. The structure of the decision tree is typically determined by the filter bank of the front end. The decision feedback techniques order the symbol hypotheses according to parameters such as the received power, SNR based, likelihood based, etc... Decisions are made sequentially on each symbol hypothesis and each decision is fed back to subtract the corresponding interference from the received data stream. The metric corresponding to a particular user's bit hypothesis at a stage in the decision tree consists of the Euclidean distance between the output of the one of the whitening filters and the hypothesized mean signal energy based on the bit

hypothesis for the user in question and the mean signal energy corresponding to the hypotheses selected for users previously tested. In addition, this metric includes the accumulation of metrics corresponding to previous decisions. The output of symbol hypothesis testing is constrained estimates of the symbols for all users in the symbol period of interest. Various efficient decision tree search strategies can be employed in symbol-hypothesis testing. For example, the M-algorithm is one such approach that restricts the number of hypotheses at each stage to a fixed number. The T-algorithm is similar in nature to the M-algorithm however it restricts the number of hypotheses by comparing the accrued metric to a threshold. Extensions of this approach to other efficient approaches to decision tree searches are within the scope of the invention.

[00104] Figure 3 shows another embodiment the present invention that further includes an option for an overloaded front end unit 328 in cooperation with the high complexity MUD 325.

[00105] The received, downconverted, digitized, raw input signal 305 is coupled to the parameter estimator 310 and the signal is also split into windows 312. The received signal is split into windows where the window size is determined by the extent in time of the intersymbol interference for a specific users and the cochannel interference between users. If the length of the channel is small then this will typically be around 3 symbols in length. If the length of the channel is longer then the length of the window could increase. The size of the window is typically determined initially by the parameter estimator as it has apriori information about the signals. The window size chosen will have an effect on the thresholds that are set for the MUD decision metric. These thresholds will be adjusted to compensate for a higher or lower numbers of bits in the window based on the window size.

[00106] Further details concerning windowing are described in the commonly owned U.S. Patent Application Serial No. 10/486871 entitled "Windowed Multiuser Detection" filed Feb. 11, 2004.

[00107] By way of illustration, assuming User 1 to User k, wherein the multiple users have various delays with respect to each other, the blocks of data for each user arrive at the receiver with an offset with respect to each other and are thus asynchronous. Each block of data consists of a series of transmitted symbols that can be of any length. Turbo MUD processing is accomplished by selecting a frame of data, which typically encompasses at least a full block of data for each user, wherein the frame of data is processed by the MUD and passed to the decoders. MUD processing requires that the processing window includes frame 'i' for user 1 and frame 'i' for user 2, etc Therefore the processing window is at least as wide as any single block of data. The step is repeated for a number of iterations for each user before proceeding to the next frame of data, including blocks 'i+1'.

[00108] On a first iteration, there are typically no symbol decisions except if training data is present and if there is decision feedback within each iteration, however on subsequent iterations, certain symbols may have been decided and known and these can be subtracted from the block of data 314.

[00109] The next step is to increment the window time 316. Complete blocks of data are typically decoded one at a time, so the MUD processing is performed for all of the symbols for a given window or frame before decoding the results and then proceeding to the next window.

[00110] Based upon the decision logic, the MUD is chosen 320 for the particular window of data. As described herein, there are multiple MUD algorithms to choose from and the optimal MUD is selected based upon certain metrics. As noted, the high complexity MUD 325 is coupled to the low complexity MUD so that an independent decision is made about which MUD technique to use for every window.

[00111] In one embodiment, one of the options includes a whitening filter such as a whitening matched filter or whitened-M algorithm pre-filter. The whitening filter may use the information from the parameter estimation unit 310 to create a filter that will ‘spread’ or ‘warp’ the raw input signal so that it is easier to distinguish between the various users’ signals that make up the received raw input signal. Supersaturated or overloaded conditions occur when the number of users exceeds the number of dimensions, wherein the number of dimensions is determined by the physical parameters of the system. The filter sends the filtered signal data to the high complexity MUD 325 such as an M-algorithm pruned tree search.

[00112] An example of the filtering designed to handle overloaded conditions is described in pending U.S. Application No. 10/423655, entitled “Deferred Decorrelating Decision-Feedback Detector For Supersaturated Communications”.

[00113] The system checks whether the window is completed 340 and if not contemplated the processing continues until the block of data in the window is completed. Once completed, the turbo MUD processing continues with the deinterleaver 350 and the bank of decoders 355. If the processing is completed 360 based upon some criteria, the hard decisions are calculated and the output bit stream 375 is transmitted for subsequent processing. If the processing is not done 360, the data is subject to re-interleave 365 and back through the loop commencing with subtracting symbol decisions 314.

[00114] Referring to **Figure 4**, a process flow is illustrated with respect to one embodiment. A raw data stream, potentially complex, is received from some a source. For the case of Code Division Multiple Access (CDMA) communications schemes, the data stream is sampled by some multiple of the chip rate. For TDMA communication schemes, the data stream is sampled at some multiple of the symbol rate. The data represents a vector of data, transferred at some rate (e.g., the symbol rate). This data is input

and processed by a parameter estimator, wherein parameter estimation is known to those skilled in the art. The purpose of the parameter estimation processing is to estimate timing, signal amplitudes, phases, polarization, frequency offset, and/or identification of transmission channels. Estimate parameters for all users are calculated **405** and passed to any filters and to the high complexity and low complexity MUD sections.

[00115] The received signals are split into a plurality of windows **410**, wherein the windows are subsets of the total received signals. The windows according to this embodiment are split into length of τ . The variable τ is determined by the length of the intersymbol interference and the length of the cochannel interference and possibly the channel length for a specific symbol time. Typically, τ is chosen such that it is larger than the intersymbol and cochannel interference and such that one to several symbols that are part of the cochannel and intersymbol interference are being estimated at the same time as the symbol of interest.

[00116] Any previous symbol decisions are then subtracted from the received signal **415**. At this point, based on some metric, the MUD for this window is selected **425**. The MUD processing is performed and symbol estimates are obtained from the selected MUD **430**.

[00117] If there are more windows to process **435**, the window is then incremented by τ **420**, and the process iterates commencing with the step of subtracting the symbol decision from the received signal.

[00118] Once all the windows have been processed, the MUD symbol estimates are deinterleaved **440**. A decoder is then applied to the symbol estimates for each user **445**. If all the symbols are above the threshold **450**, then the hard decisions are made for all the decoded bit estimates **455**.

[00119] If not all the symbols are above the threshold **450** the decoded symbol estimates are reinterleaved **470** and hard decisions are made on symbols with probabilities above the threshold **475**. The processing then

repeats the steps commencing with subtracting the symbol decision from the received signal **415**.

[00120] Referring to **Figure 5a**, one embodiment is depicted for the iterative processing of the turbo MUD loop wherein the input of know bits $r(t)$ is represented as an S matrix for all users. This data is divided into an N bit window **510**, for example, 5 bits, and any known bits are subtracted from the signal **514** thereby decreasing the number of bits and simplifying the decision tree processing for the MUD.

[00121] The decision logic unit **520** selects which MUD to use based on certain metrics as detailed herein. By way of example there are three MUDs depicted which includes a high complexity M-Algorithm algorithm **525**, a linear MUD **530**, and a low complexity “MUD” being a matched filter **535**. Note that for purposes herein, a matched filter is considered a MUD type.

[00122] Referring to **Figure 5b**, a further embodiment is illustrated wherein the number of bits remaining to decode is used as the decision metric. The input data $r(t)$ is subject to windowing **510** and known symbols are subtracted **514**. The number of simultaneous bits that have to be decoded in a MUD window is counted. In this implementation a threshold is set and compared to the number of bits to detect in each bit window. One way of determining the threshold is to determine on average how many simultaneous bits each MUD technique can correctly estimate at each iteration. This number varies from window to window because changing correlation structures mean that a different amount of bits might be subtracted off the sequence for each window. If the number of bits is above the threshold **522** a low complexity MUD **530** such as a linear MUD or a matched filter is used, if the number of bits is below the threshold **523** a high complexity MUD **524** such as an M-Algorithm, sphere decoder or ML is used. As the number of turbo iterations increases, the threshold value increases, allowing the low complexity MUD to strip off users using the turbo loop. The harder bits are then left for the higher complexity MUD

that gives better results. The high complexity MUD uses the remaining data already processed by the lower complexity MUD algorithms and thus has a smaller number of undetermined user symbol streams.

[00123] A further embodiment includes a matched filter as the low complexity MUD, wherein if the number of users left to decode is equal to 1, then the matched filter is used (assuming no intersymbol-interference). The matched filter can also be used when there are more users if the decision logic states that it will be able to correctly estimate one or several of the symbols within the window.

[00124] Referring again to **Figure 5b**, according to one embodiment, the system initially detects as many users as possible with a linear MUD **530**.

[00125] If the data is not yet fully processed **540**, the window is advanced **550** and the next N bit window is processed **510**. The known symbols are subtracted **514** and processing continues along with the MUD decision **522**, **523** and turbo MUD processing.

[00126] If all the received data is finished **540**, the BCJR **575** provides symbol estimates and probabilities of error for each symbol and decisions. If the bit estimates have reached a satisfactory level and converged to a solution **580**, the final bit estimates are transmitted along for subsequent processing. If further iterations are required, the known symbols are determined **585** and the MUD threshold can be increased **590**. The next N symbol window of data is retrieved **510** and known symbols are subtracted **514**.

[00127] In a non-iterative MUD implementation, the processing would only occur once in a single MUD loop, however this would depend upon the received data and the desired end result. In other iterative embodiments, a fixed variable such as three or four iterations can be used as the total number of iterations performed, wherein a simple counter will maintain track of iterations and stop the processing accordingly. Alternatively, there can be a buffer to store the last iteration value and

when the number of changes as compared from a last iteration to the present iteration reaches a satisfactory level the iterations are stopped.

[00128] Referring to **Figure 5c**, a further embodiment is illustrated somewhat similar to that of **Figure 5b**, but with the differences noted herein. In this embodiment, the decision logic unit **520** determines whether the high or low complexity MUD is used for processing the window of data.

[00129] There are a number of methods for making the MUD decision **520**, including having the decision based on the number of users (symbols) in a MUD window, the correlation between users, the SINR of each of the users relative to each other, the expected BER of each user for each of the MUD detectors, the SINR of each user after filtering with a specific linear MUD. This includes combinations of these decision logic methods that could trade off complexity and probability of error. For example, the MUD decision can be based on correlation between users on the first iteration and subsequent iterations of the turbo MUD can be based on the number of symbols to decode.

[00130] Another embodiment uses the structure of the eigenvalues as the decision logic to determine which MUD to use to process users. For example, the expected BER across all users is examined for the simplest MUD. If one or more users have an expected BER below a certain threshold, then that MUD is selected, otherwise the expected BER across all users is processed for the next simplest MUD. The processing continues until the complex MUD is reached and the remaining highly correlated signals are processed.

[00131] As the MUD progresses through the turbo loops, it reaches a point where the correlation structure of the remaining users is such that a linear MUD will no longer be able to detect any of the users in certain windows. At this stage however, the computational complexity has been reduced by the linear MUD by stripping bits off of the received sequence thereby allowing the ML detector or m-algorithm to perform much more efficiently.

[00132] In this particular embodiment, the MUD threshold is not increased as in **Figure 5b**, but remains the same for all iterations of the turbo MUD.

[00133] It is readily apparent that the hybrid TurboMUD technique is used in a variety of applications and with varied methods for implementing the system, and is therefore not limited to the embodiments presented herein. Variations and modifications may be made without departing from the scope of the present invention, and the reference to processing received signals is applicable to signals received from numerous implementations and not merely a wireless receiver. The hybrid Turbo-MUD technique described herein can be incorporated within numerous other MUD and TurboMUD implementations disclosed in the art and in the related pending applications.

[00134] In operation, the data is processed by the parameter estimator and then decision logic chooses the selected MUD for each window based on some metric. A window size selection is determined and the system creates a window of data. The window size can be relatively small, such as 5 bits. The processing continues and goes window by window, and for each window chooses a decoder based on the metric. Every single time it goes through the MUD on a window a decision is made.

[00135] For the lowest complexity MUD a matched filter can be used. Single user and even small number of users can employ a matched filter. And even for large number of users the matched filter can strip off certain users. Using the lower complexity MUD thus lowers the complexity and reserves the higher complexity MUD for the data that is more difficult (higher correlation) and not discernable by the lower complexity MUD. High complexity depends on number of users so by lowering the number of users reduces the complexity.

[00136] Commonly owned patent applications describing varied forms of multi-user systems that can employ the present invention are hereby incorporated by reference for all purposes and include U.S. Patent No.

6,839,390, titled "Voting System for Improving the Performance of Single-User Decoders within an Iterative Multi-User Detection System"; U.S. Application No. 10/105,918, filed 03/25/2002, titled "System for Decreasing Processing Time in an Iterative Multi-User Detector System"; U.S. Application No. 10/423655, filed 4/25/03, titled "Deferred Decorrelating Decision-Feedback Detector for Supersaturated Communications"; and U.S. Patent No. 6,704,376 entitled "Power and Confidence Ordered Low Complexity Soft Turbomud with Voting System."

[00137] One example for multiuser detection is for wireless communication, wherein a number of users (1-K) generate signals that are sent by transmitters into free space. There is normally a noise component that is introduced from the environment of a random nature in the received signal. The various signals are received at antennas (1-p), wherein there is one signal for each polarization or spatially separated feed. The signals represent directly received signals, as well as multi-path signals from the same user, and interfering signals from other users. The plurality of signals from each antenna is processed in a RF front end unit. The front end unit downconverts the higher frequency signals into baseband signals for ease of processing. The baseband signals are also digitized by analog to digital converters (A/D). The front end cooperates with the parameter estimation unit to retrieve needed information for the signals such as relative received timing offsets, carrier phase, frequency offsets, received amplitudes, and multipath structure for each of the interfering signals present in the received signal.

[00138] The MUD element consists of functional blocks that process the digital data and extract the user symbol streams. The pre-processor converts the baseband digital data into the proper format for further processing according to the desired detection scheme and whitens it. The format is often one measurement per 'dimension' per symbol. An example of this processing is a bank of matched filters followed by a measurement

whitening filter. The multi-user detection stage is detailed herein and cooperates with the error correction decoding (ECD) for iterations of the processing of the hybrid Turbo-Mud as detailed herein employing a high complexity MUD and decoder section and a low complexity MUD and decoder section.

[00139] The output of the MUD element can, optionally, be returned for a number of iterations in conjunction with the parameter estimation unit that uses the returns to improve the parameter estimates that are used to define the whitener and both the low and high complexity MUD processing. When the output K bit stream has reached a certain level of processing as described herein, the output signals are forward to the output stage (not shown). Alternatively the number of iterations can be used to fix the amount of processing.

[00140] Another application of the invention is to allow for multi-user detection for a variety of communications formats. The processing scheme of the present invention manipulates bits utilizing some apriori information so that the system has some knowledge of what the signals were supposed to have been had they been received individually and without interference or other impairments. One application which shows a non-CDMA environment is to the application involving GSM, which is a narrow band TDMA system. The user communicates over a timeslot and when the time slot is filled, another user has to wait until an open slot is available. The present invention allows reassignment of the timeslot so that signals from a second user can overlay with a first user. The only distinguishing characteristics, other than the fact that they are sending different symbol streams, would be phase, fine timing offsets, received polarization orientation, and power differences, and frequency offsets, that can be employed as described herein to differentiate user 1 from user 2. Another example relates to communications in airplanes, wherein there will be multiple users trying to communicate within a given bandwidth. The

present scheme allows these multiple users to function within the same region by picking apart attributes that distinguish one user from another.

[00141] While the discussion herein illustrates wireless cellular communications, the present invention is applicable to wired cable systems and local area networks, read/write operations of a disc drive, satellite communications and any application that benefits from extracting digital information from among many multiple interfering signals.

[00142] While the operation of the subject system has been described in terms of a wireless communications network, it has application to any situation in which digitally encoded interfering signals exist. Thus, the subject system has application to cable networks in which multiple users are seeking to communicate with a head end system simultaneously. In another embodiment, the present system is incorporated into reading storage mediums, such as computer hard drives, and to separate signals from adjacent tracks when the read head overlies portions of adjacent tracks. With the increasing density of storage devices such as hard drives, memory cards, and various storing discs, there are significant commercial advantages and incentives to place more data on smaller spaces and being able to quickly and reliably extract the data. The processing schema of the present invention is easily tailored to such an application as the data from the compact tracks of the recorded medium from the storage devices resembles wireless data bits and requires processing to promptly access and retrieve the desired data. The MUD processing with respect to the storage devices refer to the plurality of signals received when the optical head picks up the signals of the adjacent tracks of the storage mediums. The tight spacing between the tracks creates a multiple user detection problem involving the processing of the desired track signal from the other received tracks.

[00143] A further application of the present invention is in a cable modem environment. The Cable Modem Termination System provides the head end

interconnect for a plurality of individual cable modems for the transmission of data. In rough terms, the cable modem functions like a local area network (LAN). The cable modem itself combines an upstream modulator and a downstream demodulator. Most current networks are hybrid-fiber-coax networks using fiber for the main lines and coax cable connecting to the individual houses and cable modems. Inside the home, the cable modem can be connected to any of the various devices such as TV for cable television programs. It also provides Internet connectivity, interactive TV interface, smart appliance operation, and email access among other functions. The Cable Modem Termination System (CMTS) connects to the main grid that connects to a number of cable modems. The cable modems connect to a variety of devices, such as personal computer and televisions. The present invention allows the use of the data processing from the CMTS to each of a plurality of houses in a fashion similar to the base station deployment.

[00144] The foregoing description of the embodiments of the invention has been presented for the purposes of illustration and description. It is not intended to be exhaustive or to limit the invention to the precise form disclosed. Many modifications and variations are possible in light of this disclosure. It is intended that the scope of the invention be limited not by this detailed description, but rather by the claims appended hereto.

CLAIMS

What is claimed is:

- 1 1. A hybrid Multi-User Detector System for processing received
2 signals, comprising:
3 a parameter estimator coupled to said received signals
4 providing received data information;
5 a multi-user detector decision unit coupled to said parameter
6 estimator and said received signals;
7 at least two multi-user detectors coupled to said parameter
8 estimator and said multi-user detector decision unit, said
9 multi-user detector decision unit using decision criteria to
10 determine a selected multi-user detector, wherein said selected
11 multi-user detector outputs a plurality of information streams,
12 one stream corresponding to each of said received signals; and
13 a bank of decoders coupled to said plurality of information
14 streams, wherein said decoders output a plurality of improved
15 information streams.
- 1 2. The System according to Claim 1 wherein said plurality of improved
2 information streams are fed back to said multi-user detector decision
3 unit until a final condition is reached and said bank of decoders
4 output a final data stream.
- 1 3. The System according to Claim 1 wherein said design criteria is
2 based upon at least one threshold selected from at least one of the
3 group consisting of: number of symbols, correlation matrix between
4 users, expected bit error rate, eigendecomposition of correlation
5 matrix, signal to interference plus noise ratio, and expected SINR.
- 1 4. The System according to Claim 3 wherein said threshold is

2 dynamically changeable.

1 5. The System according to Claim 1 wherein said at least two multiuser
2 detectors are selected from the group consisting of: M-algorithm,
3 sphere decoder, T-algorithm, FANO, reduced state Viterbi, Maximum
4 Likelihood, matched filter, minimum mean squared error (MMSE),
5 decorrelator, and combinations thereof.

1 6. The System according to Claim 1, further comprising an interleaver
2 unit and a deinterleaver unit coupled between said bank of decoders
3 and said multi-user detectors.

1 7. The System according to Claim 2, wherein said final condition is
2 determined by one of a fixed number of iterations and an allowable
3 performance level.

1 8. The System according to Claim 1, further comprising a filter unit
2 coupled to said received signals, wherein said filter unit is coupled
3 to said multi-user detector decision unit.

1 9. The System according to Claim 1, further comprising a hard decision
2 unit coupled to said bank of decoders and producing a final data
3 stream.

1 10. A hybrid receiver for processing a plurality of received signals, said
2 receiver comprising:

3 a parameter estimation unit coupled to said received signals,
4 wherein said parameter estimation unit extracts received signal
5 information;

6 a multi-user detector decision unit coupled to said parameter
7 estimator and said received signals, wherein said multi-user

8 detector decision unit selects a multi-user detector based upon
9 at least one threshold;
10 a low complexity multi-user detector switchably coupled by
11 said multi-user detector decision unit, wherein said low
12 complexity multi-user detector outputs a plurality of low
13 complexity processed information streams;
14 a medium complexity multi-user detector switchably coupled
15 by said multi-user detector decision unit, wherein said medium
16 complexity multi-user detector outputs a plurality of medium
17 complexity processed information streams;
18 a high complexity multi-user detector switchably coupled by
19 said multi-user detector decision unit, wherein said high
20 complexity multi-user detector outputs a plurality of high
21 complexity processed information streams; and
22 a bank of decoders coupled to said plurality of low complexity
23 processed information streams, said plurality of medium
24 complexity processed information streams, and said plurality
25 of high complexity processed information streams, wherein
26 said decoders output a plurality of refined information streams.

1 11. The hybrid receiver according to Claim 10, further comprising a
2 front end section coupled to said received signals and to said
3 received signal information which filters said received signals.

1 12. The hybrid receiver according to Claim 10, wherein said plurality of
2 refined information streams are fed back to said multi-user detector
3 decision unit for iterative processing until a final condition is
4 reached and said bank of error correction decoders output a final
5 plurality of bit streams.

1 13. The hybrid receiver according to Claim 10, wherein said multi-user
2 detector decision unit makes a selection determined by design

3 criteria based upon at least one threshold selected from at least one
4 of the group consisting of: number of symbols, correlation matrix
5 between users, expected bit error rate, eigendecomposition of
6 correlation matrix, signal to interference plus noise ratio, and
7 expected SINR.

1 14. The hybrid receiver according to Claim 10, wherein said threshold is
2 changeable.

1 15. The hybrid receiver according to Claim 12, wherein said final
2 condition is one of a fixed number of iterations and an allowable
3 performance level.

1 16. The hybrid receiver according to Claim 10, further comprising a hard
2 decision unit coupled to said bank of decoders and producing a final
3 data stream.

1 17. A method for processing signals from multiple users with raw
2 digitized data, comprising:
3 performing parameter estimation of said raw digitized data;
4 grabbing a window of bits from said raw digitized data;
5 subtracting any known bits from said window of bits;
6 selecting a multi-user detector;
7 estimating unknown bits from said window of bits using said
8 multi-user detector;
9 incrementing to a next window of bits;
10 repeating said steps of subtracting, selecting, estimating and
11 incrementing until there are no more windows and outputting a
12 set of symbol estimates.

1 18. The method according to claim 17, wherein said multi-user detector
2 is selectable from the group consisting of high complexity multi-user

3 detectors, medium complexity multi-user detectors, low complexity
4 multi-user detectors and matched filters.

1 19. The method according to claim 17, further comprising determining a
2 size of said window by at least one of an intersymbol interference
3 length, a channel length, and a cochannel interference length.

1 20. The method according to claim 17, further comprising checking said
2 symbol estimates for a threshold condition;
3 outputting a final bit stream for each user if passing said
4 threshold condition, and repeating said steps of subtracting,
5 selecting, estimating and incrementing if failing said threshold
6 condition.

COMBINATIONAL HYBRID TURBO-MUD

ABSTRACT

[00145] A high quality real-time Turbo-Mud processing system that chooses between a high complexity multi-user detectors that results in better estimates of the bit streams and computationally low linear-based-MUD/Turbo-MUD at each MUD window in each Turbo Iteration. IN one embodiment this technique optimizes both the BER and the computational complexity of the receiver by using low complexity MUDs to reduce the number of symbols that the high complexity MUDs need to process. The present invention also provides an efficient means of estimating symbols transmitted in a multi-user environment in overloaded or super-saturated conditions.

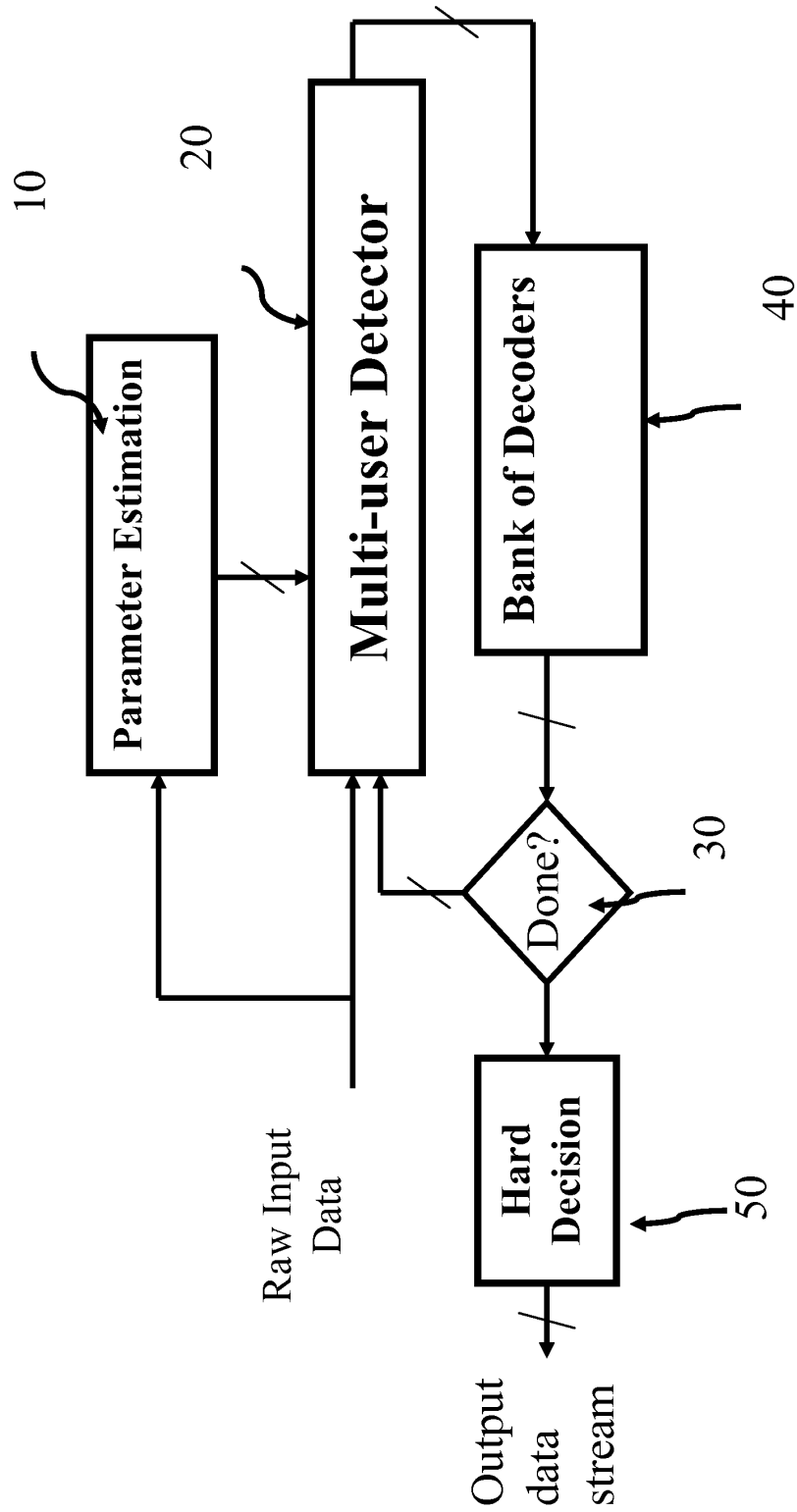


Figure 1
(Prior Art)

2/7

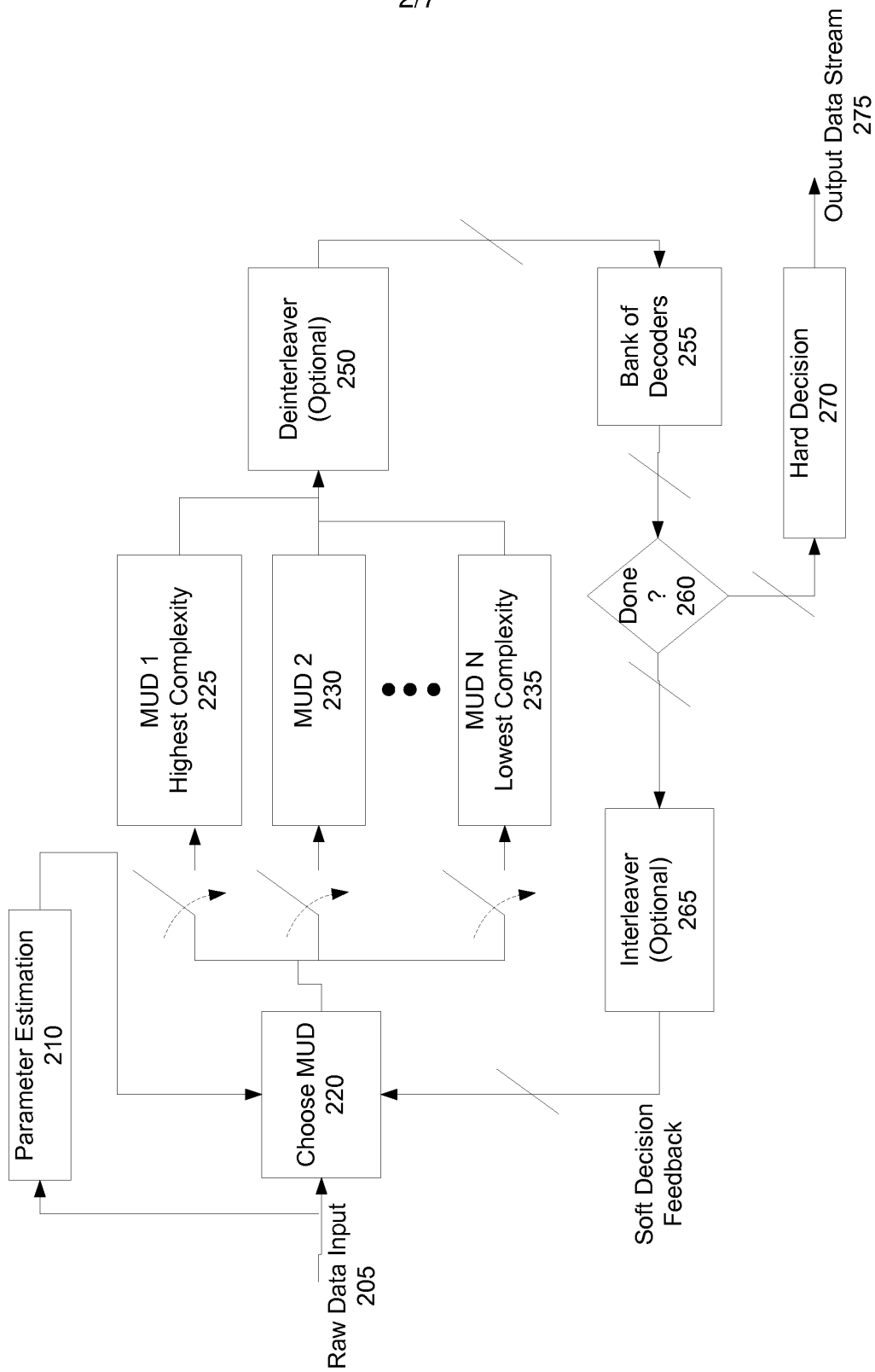


Figure 2

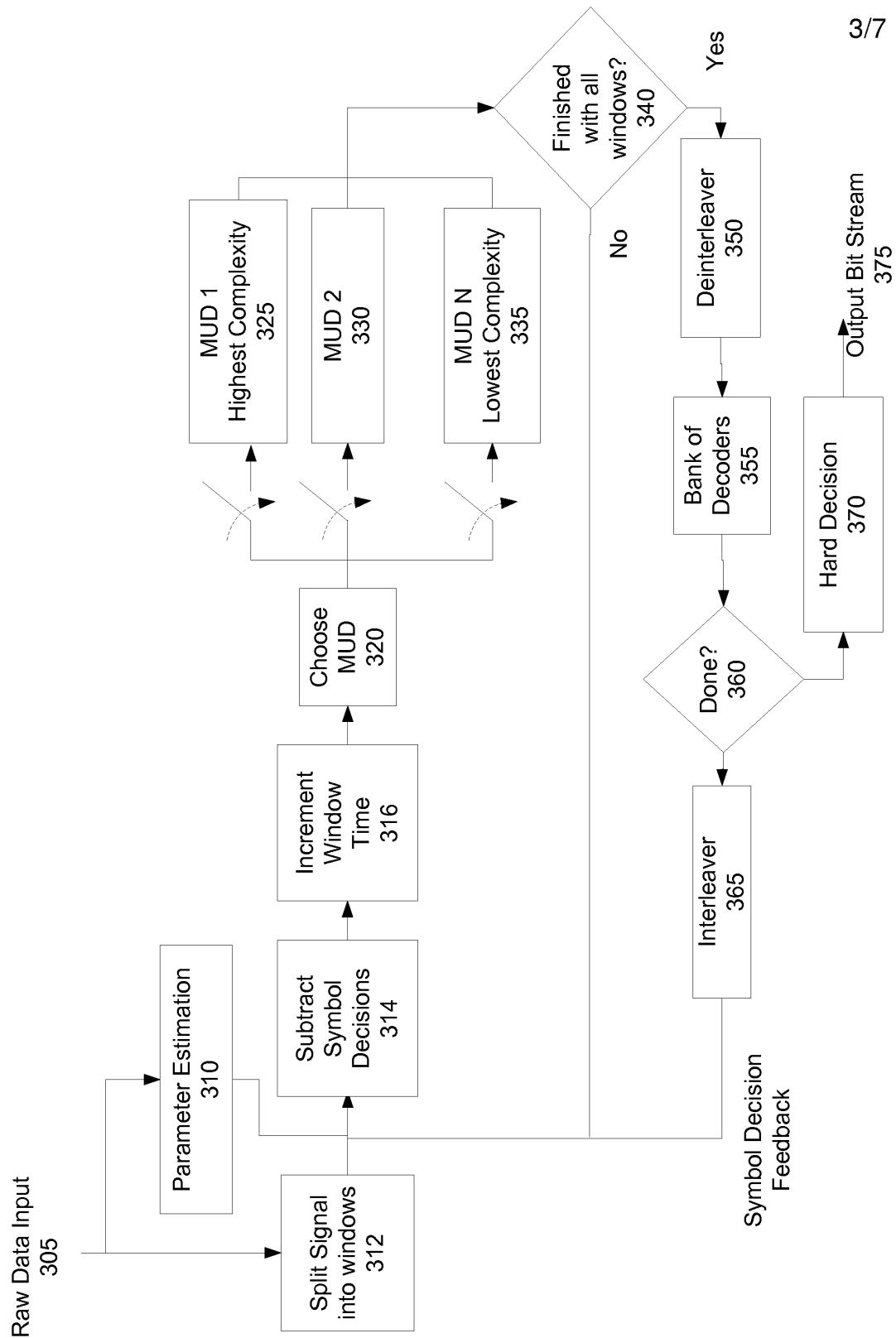


Figure 3

3/7

4/7

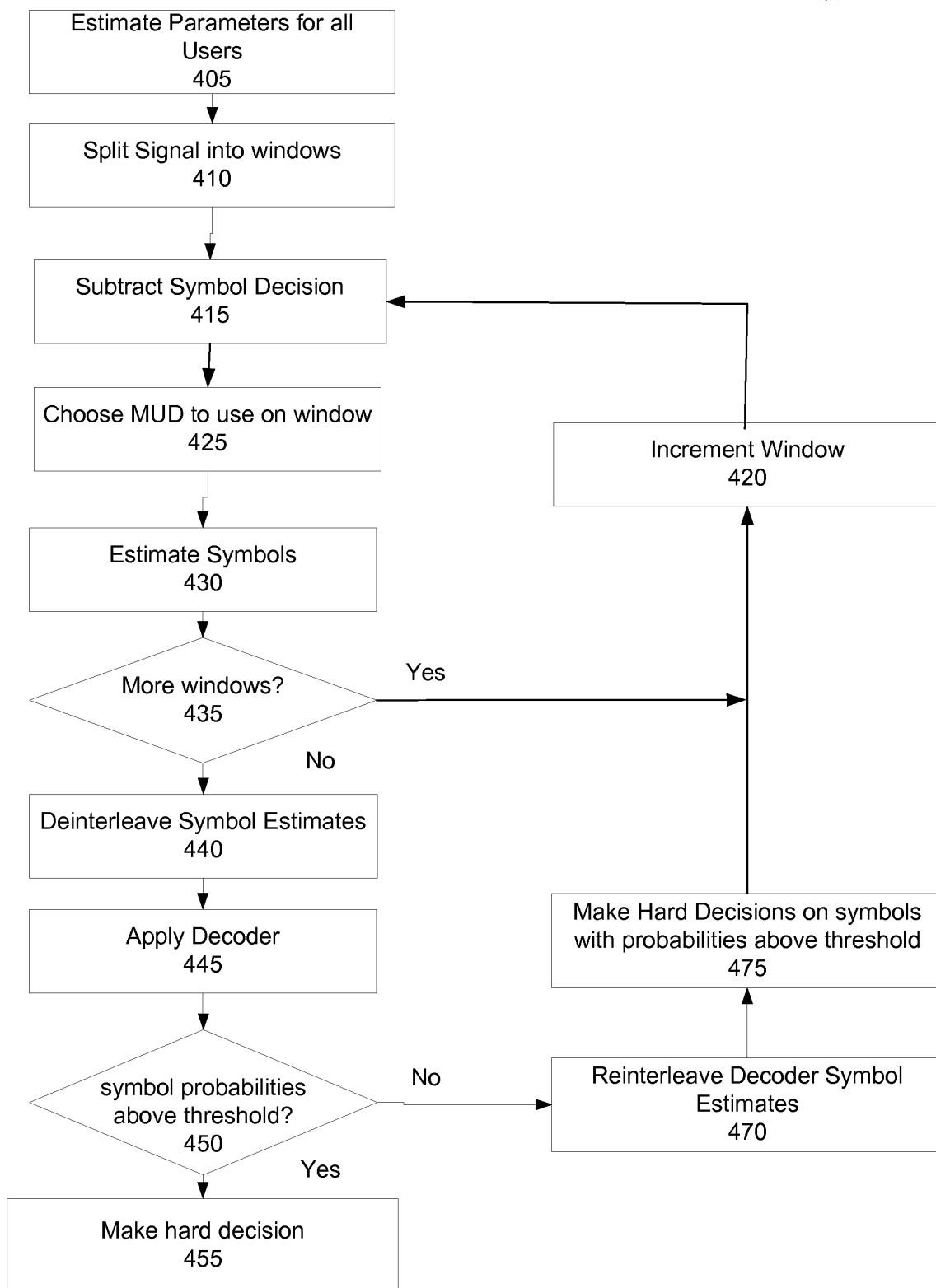


Figure 4

5/7

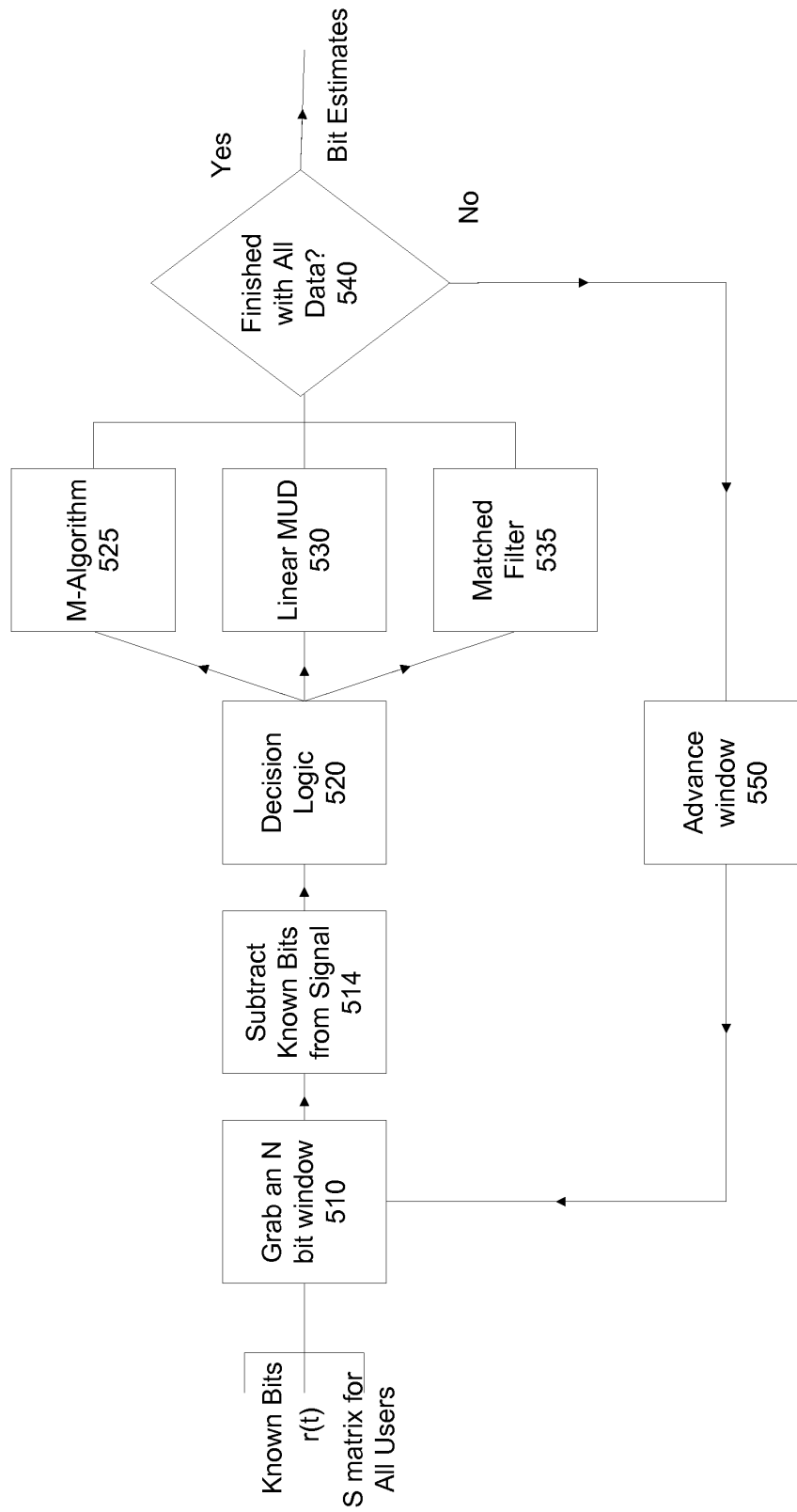


Figure 5a

6/7

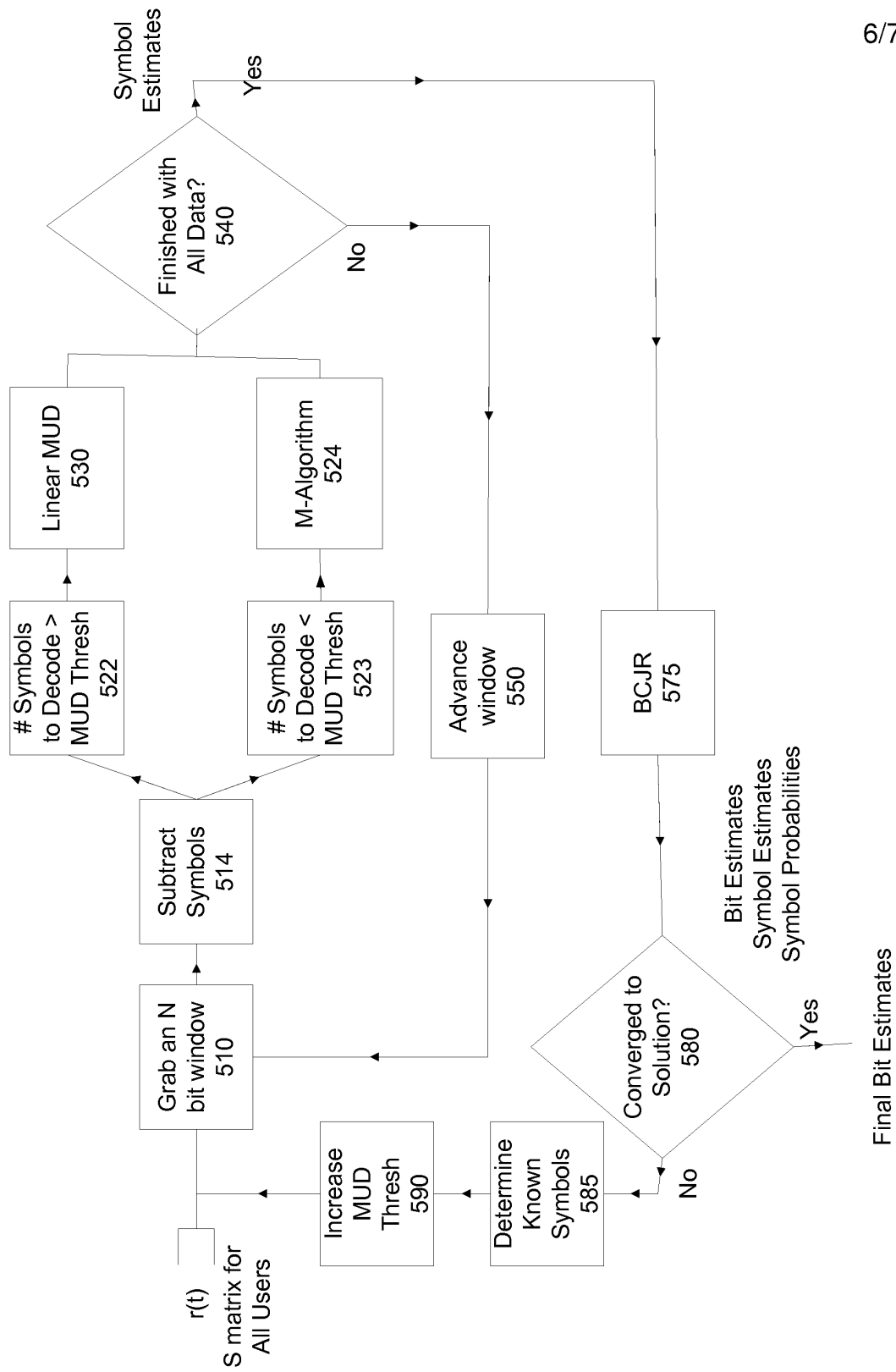


Figure 5b

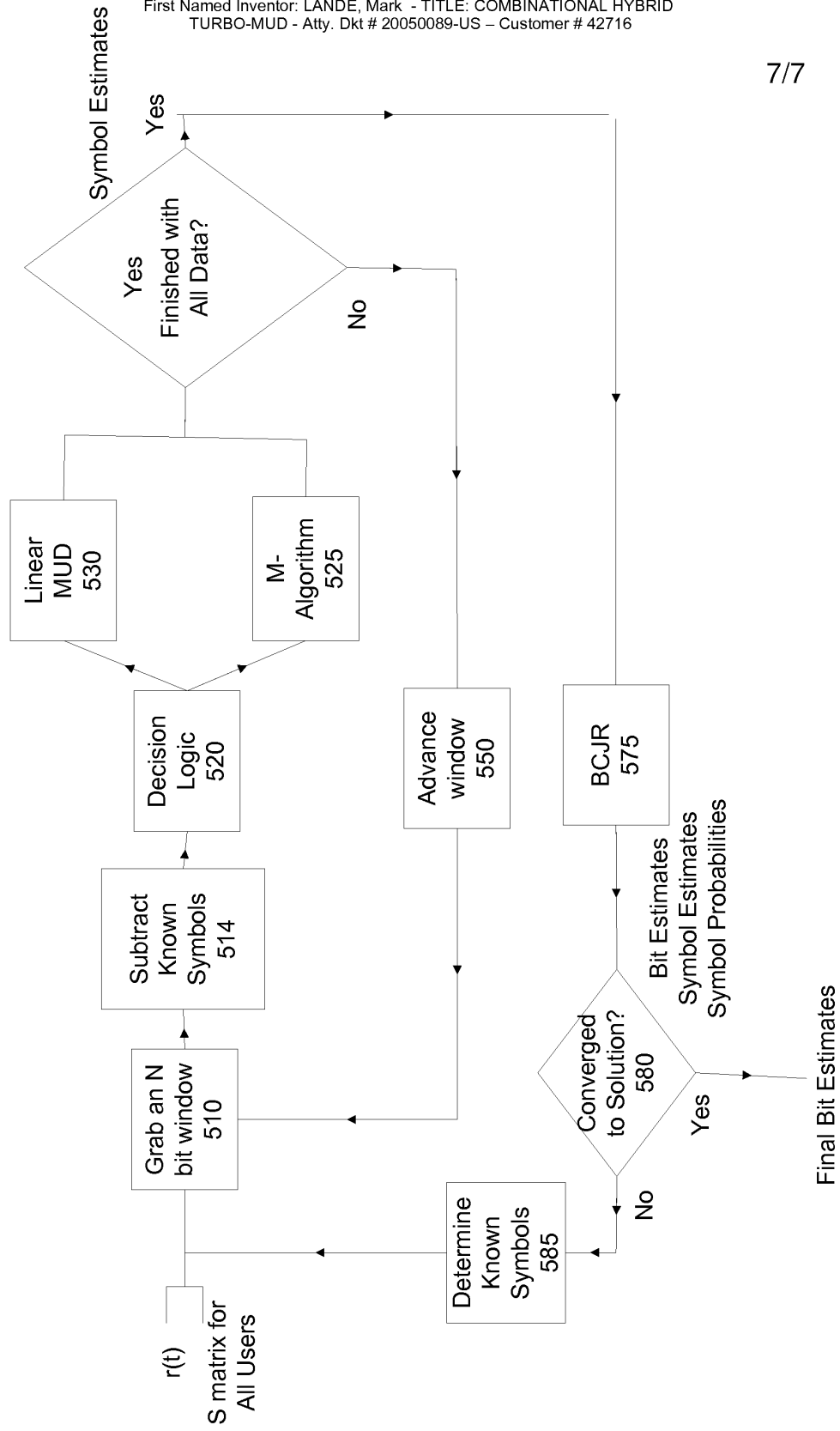
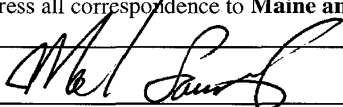


Figure 5c

DECLARATION AND POWER OF ATTORNEY FOR PATENT APPLICATION

As a below-named inventor, I hereby declare that:

- My residence, post-office addresses and citizenship are as stated below next to my name.
- I believe that I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought by the application for U.S. Letters Patent entitled: **COMBINATIONAL HYBRID TURBO-MUD**, the specification of which is attached hereto; or filed on _____ with Serial No. _____; and identified by Docket No. **20050089-US of BAE SYSTEMS Information and Electronic Systems Integration Inc.**
- I hereby state that I have reviewed and understand the contents of the above-identified application specification, including the claims.
- I acknowledge the duty to disclose information that is material to the examination of this application in accordance with Title 37, Code of Federal Regulations, paragraph 1.56(a).
- I hereby claim foreign priority benefits under Title 35, United States Code 119 of any foreign application(s) for patent or inventor's certificate listed below and have also identified below any foreign application for patent or inventor's certificate having a filing date before that of the application on which priority is claimed: NONE
- I hereby claim the benefit under 35 U.S.C. 119(e) of any United States provisional application(s) listed below: NONE
- I hereby claim the benefit under 35 U.S.C. 120 of any United States application(s), or 365(c) of any PCT international application designating the United States of America, listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in the prior United States or PCT International application in the manner provided by the first paragraph of 35 U.S.C. 112, I acknowledge the duty to disclose information which is material to patentability as defined in 37 CFR 1.56 which became available between the filing date of the prior application and the national or PCT international filing date of this application: NONE
- I hereby declare that all statements made herein of my knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment or both under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.
- **Power of Attorney:** I hereby appoint the following persons as our attorney, with full power of substitution, delegation and revocation, to prosecute this application, to make alterations and amendments therein, to receive the patent and to transact all business in the Patent and Trademark Office connected therewith: **Customer Number 42716 - Scott J. Asmus, Reg. No. 42,269; Daniel J. Long, Reg. No. 29,404; and Andrew P. Cernota, Reg. No. 52,711**
- Please direct all telephone calls to **Scott J. Asmus or Andrew P. Cernota at (603) 886-6100.**
- Please address all correspondence to **Maine and Asmus, PO Box 3445, Nashua, NH 03061-3445.**

Signature of Inventor:	
Name:	Mark Lande
Date:	8/29/06
Residence:	49 Ledgewood Hills Drive Nashua, NH 03062
Citizenship:	United States
P. O. Address:	Same as Residence

Electronic Patent Application Fee Transmittal				
Application Number:				
Filing Date:				
Title of Invention:		COMBINATIONAL HYBRID TURBO-MUD		
First Named Inventor:		Mark Lande		
Filer:		Scott Joseph Asmus/Debra Stengel		
Attorney Docket Number:		20050089-US		
Filed as Large Entity				
Utility Filing Fees				
Description	Fee Code	Quantity	Amount	Sub-Total in USD(\$)
Basic Filing:				
Utility application filing	1011	1	300	300
Utility Search Fee	1111	1	500	500
Utility Examination Fee	1311	1	200	200
Pages:				
Claims:				
Miscellaneous-Filing:				
Petition:				
Patent-Appeals-and-Interference:				

Description	Fee Code	Quantity	Amount	Sub-Total in USD(\$)
Post-Allowance-and-Post-Issuance:				
Extension-of-Time:				
Miscellaneous:				
Total in USD (\$)				1000

Electronic Acknowledgement Receipt

EFS ID:	1202602
Application Number:	11532125
Confirmation Number:	2294
Title of Invention:	COMBINATIONAL HYBRID TURBO-MUD
First Named Inventor:	Mark Lande
Customer Number:	42716
Filer:	Scott Joseph Asmus/Debra Stengel
Filer Authorized By:	Scott Joseph Asmus
Attorney Docket Number:	20050089-US
Receipt Date:	15-SEP-2006
Filing Date:	
Time Stamp:	09:56:39
Application Type:	Utility
International Application Number:	

Payment information:

Submitted with Payment	yes
Payment was successfully received in RAM	\$1000
RAM confirmation Number	853
Deposit Account	190130
The Director of the USPTO is hereby authorized to charge indicated fees and credit any overpayment as follows: Charge any Additional Fees required under 37 C.F.R. Section 1.16 and 1.17	

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)	Multi Part	Pages
1	Transmittal letter	20050089-US_Transmittal_Letter.pdf	90053	no	2
Warnings:					
Information:					
2	Application Data Sheet	US_ADS_Form_SB_14.pdf	915118	no	4
Warnings:					
Information:					
3		20050089_US_Final_Final_Final.pdf	305984	yes	48
	Multipart Description				
	Doc Desc		Start	End	
	Specification		1	42	
	Confirmation of Hearing by Appellant		43	47	
	Abstract		48	48	
Warnings:					
Information:					
4	Drawings	20050089-US_Figures_1-5.pdf	477202	no	7
Warnings:					
Information:					
5	Oath or Declaration filed	20050089-US_Declaration.pdf	73363	no	1
Warnings:					
Information:					
6	Fee Worksheet (PTO-875)	fee-info.pdf	8335	no	2
Warnings:					
Information:					
Total Files Size (in bytes):			1870055		

This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503.

New Applications Under 35 U.S.C. 111

If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.

National Stage of an International Application under 35 U.S.C. 371

If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

Electronic Acknowledgement Receipt

EFS ID:	1202602
Application Number:	11532125
Confirmation Number:	2294
Title of Invention:	COMBINATIONAL HYBRID TURBO-MUD
First Named Inventor:	Mark Lande
Customer Number:	42716
Filer:	Scott Joseph Asmus/Debra Stengel
Filer Authorized By:	Scott Joseph Asmus
Attorney Docket Number:	20050089-US
Receipt Date:	15-SEP-2006
Filing Date:	
Time Stamp:	09:56:39
Application Type:	Utility
International Application Number:	

Payment information:

Submitted with Payment	yes
Payment was successfully received in RAM	\$1000
RAM confirmation Number	853
Deposit Account	190130
The Director of the USPTO is hereby authorized to charge indicated fees and credit any overpayment as follows: Charge any Additional Fees required under 37 C.F.R. Section 1.16 and 1.17	

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)	Multi Part	Pages
1	Transmittal letter	20050089-US_Transmittal_Letter.pdf	90053	no	2
Warnings:					
Information:					
2	Application Data Sheet	US_ADS_Form_SB_14.pdf	915118	no	4
Warnings:					
Information:					
3		20050089_US_Final_Final_Final.pdf	305984	yes	48
	Multipart Description				
	Doc Desc		Start	End	
	Specification		1	42	
	Confirmation of Hearing by Appellant		43	47	
	Abstract		48	48	
Warnings:					
Information:					
4	Drawings	20050089-US_Figures_1-5.pdf	477202	no	7
Warnings:					
Information:					
5	Oath or Declaration filed	20050089-US_Declaration.pdf	73363	no	1
Warnings:					
Information:					
6	Fee Worksheet (PTO-875)	fee-info.pdf	8335	no	2
Warnings:					
Information:					
Total Files Size (in bytes):			1870055		

This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503.

New Applications Under 35 U.S.C. 111

If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.

National Stage of an International Application under 35 U.S.C. 371

If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it contains a valid OMB control number.

INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Not for submission under 37 CFR 1.99)	Application Number		11532125
	Filing Date		2006-09-15
	First Named Inventor	LANDE, Mark	
	Art Unit	2611	
	Examiner Name		
	Attorney Docket Number	20050089-US	

U.S. PATENTS						Remove
Examiner Initial*	Cite No	Patent Number	Kind Code ¹	Issue Date	Name of Patentee or Applicant of cited Document	Pages, Columns, Lines where Relevant Passages or Relevant Figures Appear
	1	5506861		1996-04-09	Bottomley	
	2	5563897		1996-10-08	Pyndiah et al.	
	3	6122269		2000-09-19	Wales	
	4	6151370		2000-11-21	Wei	
	5	6167022		2000-12-26	Ishida et al.	
	6	6704376	B2	2004-03-09	Mills et al.	
	7	6898248	B1	2005-05-24	Elgamal et al.	
	8	6182261	B1	2001-01-30	Haller et al.	
If you wish to add additional U.S. Patent citation information please click the Add button.						Add

INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Not for submission under 37 CFR 1.99)	Application Number		11532125
	Filing Date		2006-09-15
	First Named Inventor	LANDE, Mark	
	Art Unit	2611	
	Examiner Name		
	Attorney Docket Number	20050089-US	

U.S.PATENT APPLICATION PUBLICATIONS							Remove
Examiner Initial*	Cite No	Publication Number	Kind Code ¹	Publication Date	Name of Patentee or Applicant of cited Document	Pages,Columns,Lines where Relevant Passages or Relevant Figures Appear	
	1	20030187928	A1	2003-10-02	MacLeod et al.		
	2	20040022336	A1	2004-02-05	Yu et al.		
	3	20050018793	A1	2005-01-27	Learned		

If you wish to add additional U.S. Published Application citation information please click the Add button.

Add

FOREIGN PATENT DOCUMENTS								Remove
Examiner Initial*	Cite No	Foreign Document Number ³	Country Code ² j	Kind Code ⁴	Publication Date	Name of Patentee or Applicant of cited Document	Pages,Columns,Lines where Relevant Passages or Relevant Figures Appear	T ⁵
	1							☐

If you wish to add additional Foreign Patent Document citation information please click the Add button.

Add

NON-PATENT LITERATURE DOCUMENTS				Remove
Examiner Initials*	Cite No	Include name of the author (in CAPITAL LETTERS), title of the article (when appropriate), title of the item (book, magazine, journal, serial, symposium, catalog, etc), date, pages(s), volume-issue number(s), publisher, city and/or country where published.	T ⁵	
	1	POTTIE, Gregory J et al., "A Comparison of Reduced Complexity Decoding Algorithms for Trellis Codes", IEEE on Selected Areas in Communications, December 1989, pp. 1369-1380, Vol. 7, No. 9.	☐	
	2	BERROU, Claude et al., "Near Optimum Error Correcting Coding and Decoding: Turbo-Codes", IEEE Trans. on Communications, October 1996, pp. 1261-1271, Vol. 44, No. 10.	☐	

INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Not for submission under 37 CFR 1.99)	Application Number		11532125
	Filing Date		2006-09-15
	First Named Inventor	LANDE, Mark	
	Art Unit	2611	
	Examiner Name		
	Attorney Docket Number	20050089-US	

3	BERROU, Claude et al., "Near Shannon Limit Error-Correcting Coding and Decoding: Turbo Codes(1)", IEEE, 1993, pp. 1064-1070.	☐
4	DUANYI, Wang et al., "Low-Complexity MAP Decoding for Turbo Codes", Vehicular Technology Conference, 2000, pp. 1035-1039, Princeton University, Princeton NJ.	☐
5	HERZOG, Rupert et al., "Iterative Decoding and Despreading Improves CDMA-Systems Using M-ary Orthogonal Modulation and FEC", IEEE, 1997, pp. 909-913.	☐
6	DAS, Suman et al., "Computationally Efficient Iterative Multiuser Detection and Decoding", Asilomar, 1998, pp. 631-634, Department of Electrical and Computer Engineering, Rice University, Houston Texas.	☐
7	WANG, Xiaodong et al., "Iterative (Turbo) Soft Interference Cancellation and Decoding for Coded CDMA", IEEE Trans. on Communications, July 1999, pp. 1046-1061, Vol. 47, No. 7.	☐
8	POOR, Vincent, "Turbo Multiuser Detection: An Overview", Department of Electrical Engineering, IEEE 6th International Symposium on Spread-Spectrum Tech. & Appliances, September 2000, pp. 583-587, Princeton University, Princeton NJ.	☐
9	ALEXANDER, Paul et al., "Iterative Multiuser Interference Reduction: Turbo CDMA", IEEE Transactions on Communications, July 1999, pp. 1008-1014, Vol. 47, No. 7.	☐
10	HAGENAUER, Joachim et al., "A Viterbi Algorithm with Soft-Detection Outputs and its Applications", IEEE, 1989, pp. 1680-1686.	☐
11	ROBERTSON, Patrick, "A Comparison of Optimal and Sub-Optimal MAP Decoding Algorithms Operating in the Log Domain", IEEE, 1995, pp. 1009-1013.	☐
12	VERDU, S., "Minimum Probability of Error for Asynchronous Gaussian Multiple-Access Channels", IEEE Transactions on Information Theory, January 1986, pp. 85-96, Vol. IT-32, No. 1.	☐
13	LUPAS, Ruxandra et al., "Linear Multiuser Detectors for Synchronous Code-Division Multiple-Access Channels", IEEE Transactions on Information Theory, January 1989, pp. 123-136, Vol. 35, No. 1.	☐

INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Not for submission under 37 CFR 1.99)	Application Number		11532125
	Filing Date		2006-09-15
	First Named Inventor	LANDE, Mark	
	Art Unit	2611	
	Examiner Name		
Attorney Docket Number		20050089-US	

14	WEI, Lei et al., "Synchronous DS-SSMA System with Improved Decorrelating Decision-Feedback Multiuser Detection", IEEE Transactions on Vehicular Technology, August 1994, pp. 767-772, Vol. 43, No. 3.	☐
15	VARANASI, Mahesh K. et al., "Near-Optimum Detection in Synchronous Code-Division Multiple-Access Systems", IEEE Transactions on Communications, May 1991, pp. 725-736, Vol. 39, No. 5.	☐
16	DUEL-HALLEN, Alexandra, "Decorrelating Decision-Feedback Multiuser Detector for Synchronous Code-Division Multiple-Access Channel", IEEE Transactions on Communications, February 1993, pp. 285-290, Vol. 41, No. 2.	☐
17	LUPAS, Ruxandra et al., "Near-Far Resistance of Multiuser Detectors in Asynchronous Channels", IEEE Transactions on Communications, April 1990, pp. 496-508, Vol. 38, No. 4.	☐

If you wish to add additional non-patent literature document citation information please click the Add button

EXAMINER SIGNATURE

Examiner Signature	Date Considered
--------------------	-----------------

*EXAMINER: Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through a citation if not in conformance and not considered. Include copy of this form with next communication to applicant.

¹ See Kind Codes of USPTO Patent Documents at www.USPTO.GOV or MPEP 901.04. ² Enter office that issued the document, by the two-letter code (WIPO Standard ST.3). ³ For Japanese patent documents, the indication of the year of the reign of the Emperor must precede the serial number of the patent document. ⁴ Kind of document by the appropriate symbols as indicated on the document under WIPO Standard ST.16 if possible. ⁵ Applicant is to place a check mark here if English language translation is attached.

INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Not for submission under 37 CFR 1.99)	Application Number		11532125
	Filing Date		2006-09-15
	First Named Inventor	LANDE, Mark	
	Art Unit	2611	
	Examiner Name		
	Attorney Docket Number	20050089-US	

CERTIFICATION STATEMENT

Please see 37 CFR 1.97 and 1.98 to make the appropriate selection(s):

☐ That each item of information contained in the information disclosure statement was first cited in any communication from a foreign patent office in a counterpart foreign application not more than three months prior to the filing of the information disclosure statement. See 37 CFR 1.97(e)(1).

OR

☐ That no item of information contained in the information disclosure statement was cited in a communication from a foreign patent office in a counterpart foreign application, and, to the knowledge of the person signing the certification after making reasonable inquiry, no item of information contained in the information disclosure statement was known to any individual designated in 37 CFR 1.56(c) more than three months prior to the filing of the information disclosure statement. See 37 CFR 1.97(e)(2).

☐ See attached certification statement.

☐ Fee set forth in 37 CFR 1.17 (p) has been submitted herewith.

☒ None

SIGNATURE

A signature of the applicant or representative is required in accordance with CFR 1.33, 10.18. Please see CFR 1.4(d) for the form of the signature.

Signature	/Scott J. Asmus, Reg. No. 42,269/	Date (YYYY-MM-DD)	2006-10-24
Name/Print	Scott J. Asmus	Registration Number	42269

This collection of information is required by 37 CFR 1.97 and 1.98. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 1 hour to complete, including gathering, preparing and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

Privacy Act Statement

The Privacy Act of 1974 (P.L. 93-579) requires that you be given certain information in connection with your submission of the attached form related to a patent application or patent. Accordingly, pursuant to the requirements of the Act, please be advised that: (1) the general authority for the collection of this information is 35 U.S.C. 2(b)(2); (2) furnishing of the information solicited is voluntary; and (3) the principal purpose for which the information is used by the U.S. Patent and Trademark Office is to process and/or examine your submission related to a patent application or patent. If you do not furnish the requested information, the U.S. Patent and Trademark Office may not be able to process and/or examine your submission, which may result in termination of proceedings or abandonment of the application or expiration of the patent.

The information provided by you in this form will be subject to the following routine uses:

1. The information on this form will be treated confidentially to the extent allowed under the Freedom of Information Act (5 U.S.C. 552) and the Privacy Act (5 U.S.C. 552a). Records from this system of records may be disclosed to the Department of Justice to determine whether the Freedom of Information Act requires disclosure of these records.
2. A record from this system of records may be disclosed, as a routine use, in the course of presenting evidence to a court, magistrate, or administrative tribunal, including disclosures to opposing counsel in the course of settlement negotiations.
3. A record in this system of records may be disclosed, as a routine use, to a Member of Congress submitting a request involving an individual, to whom the record pertains, when the individual has requested assistance from the Member with respect to the subject matter of the record.
4. A record in this system of records may be disclosed, as a routine use, to a contractor of the Agency having need for the information in order to perform a contract. Recipients of information shall be required to comply with the requirements of the Privacy Act of 1974, as amended, pursuant to 5 U.S.C. 552a(m).
5. A record related to an International Application filed under the Patent Cooperation Treaty in this system of records may be disclosed, as a routine use, to the International Bureau of the World Intellectual Property Organization, pursuant to the Patent Cooperation Treaty.
6. A record in this system of records may be disclosed, as a routine use, to another federal agency for purposes of National Security review (35 U.S.C. 181) and for review pursuant to the Atomic Energy Act (42 U.S.C. 218(c)).
7. A record from this system of records may be disclosed, as a routine use, to the Administrator, General Services, or his/her designee, during an inspection of records conducted by GSA as part of that agency's responsibility to recommend improvements in records management practices and programs, under authority of 44 U.S.C. 2904 and 2906. Such disclosure shall be made in accordance with the GSA regulations governing inspection of records for this purpose, and any other relevant (i.e., GSA or Commerce) directive. Such disclosure shall not be used to make determinations about individuals.
8. A record from this system of records may be disclosed, as a routine use, to the public after either publication of the application pursuant to 35 U.S.C. 122(b) or issuance of a patent pursuant to 35 U.S.C. 151. Further, a record may be disclosed, subject to the limitations of 37 CFR 1.14, as a routine use, to the public if the record was filed in an application which became abandoned or in which the proceedings were terminated and which application is referenced by either a published application, an application open to public inspections or an issued patent.
9. A record from this system of records may be disclosed, as a routine use, to a Federal, State, or local law enforcement agency, if the USPTO becomes aware of a violation or potential violation of law or regulation.

Electronic Acknowledgement Receipt	
EFS ID:	1267953
Application Number:	11532125
International Application Number:	
Confirmation Number:	2294
Title of Invention:	COMBINATIONAL HYBRID TURBO-MUD
First Named Inventor/Applicant Name:	Mark Lande
Customer Number:	42716
Filer:	Scott Joseph Asmus/Jacqueline Judkins
Filer Authorized By:	Scott Joseph Asmus
Attorney Docket Number:	20050089-US
Receipt Date:	24-OCT-2006
Filing Date:	15-SEP-2006
Time Stamp:	14:32:43
Application Type:	Utility

Payment information:

Submitted with Payment	no
------------------------	----

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)	Multi Part /.zip	Pages (if appl.)
1	Transmittal letter	IDS_Transmittal_Before3Mths.pdf	91744	no	2

Warnings:

Information:					
2	NPL Documents	AComparisonOfOptimal.pdf	370668	no	5
Warnings:					
Information:					
3	NPL Documents	AViterbiAlgorithm.pdf	395264	no	7
Warnings:					
Information:					
4	NPL Documents	ComparisonOfReducedComplexity.pdf	802408	no	12
Warnings:					
Information:					
5	NPL Documents	ComputationallyEfficient.pdf	229332	no	4
Warnings:					
Information:					
6	NPL Documents	Decorrelating_Decision.pdf	417063	no	6
Warnings:					
Information:					
7	NPL Documents	IterativeDecoding.pdf	439910	no	5
Warnings:					
Information:					
8	NPL Documents	IterativeMultiuserInterference.pdf	661317	no	7
Warnings:					
Information:					
9	NPL Documents	IterativeTurbo.pdf	1021417	no	16
Warnings:					
Information:					
10	NPL Documents	LinearMultiuserDetectors.pdf	858852	no	14
Warnings:					

Information:					
11	NPL Documents	LowComplexityMap.pdf	287563	no	5
Warnings:					
Information:					
12	NPL Documents	MinimumProbability.pdf	905973	no	12
Warnings:					
Information:					
13	NPL Documents	near_optimum_detect.pdf	848498	no	11
Warnings:					
Information:					
14	NPL Documents	NearFarResistance.pdf	871025	no	13
Warnings:					
Information:					
15	NPL Documents	NearOptimumError.pdf	728483	no	11
Warnings:					
Information:					
16	NPL Documents	NearShannonLimitError.pdf	393064	no	7
Warnings:					
Information:					
17	NPL Documents	synchronous_ds_ssma.pdf	383500	no	6
Warnings:					
Information:					
18	NPL Documents	TurboMultiuserDetection.pdf	499338	no	5
Warnings:					
Information:					
19	Information Disclosure Statement (IDS) Filed	US_IDS_Form__SB_08a.pdf	853963	no	6
Warnings:					

Information:	
Total Files Size (in bytes):	11059382
This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503. <u>New Applications Under 35 U.S.C. 111</u> If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application. <u>National Stage of an International Application under 35 U.S.C. 371</u> If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.	

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In Re Application of: LANDE, Mark Group Art Unit: 2611

Serial No. 11/532,125 Examiner:

Filing or 371 (c) Date: 09/15/2006 Atty. Dkt. No: 20050089-US

For: COMBINATIONAL HYBRID TUBO-MUD

To: Mail Stop Amendment
Commissioner for Patents
PO Box 1450
Alexandria, VA 22313-1450

42716

Commissioner:

INFORMATION DISCLOSURE STATEMENT TRANSMITTAL

Applicants submit this statement, the attached 6 sheet(s) of form PTO/SB/08A, and 17 references and/or other information, in accordance to the duty of disclosure under 37 C.F.R. §§1.56,1.97, and 1.98, and requests consideration hereof. Please enter in the above application and communicate in all related matters with the undersigned.

Compliance with 37 C.F.R. §1.97: This Information Disclosure Statement is filed within three (3) months of the filing date of a National Application or before the mailing date of a first office action on the merits. No fee or certification is required.

Information Cited: The Applicants hereby make of record in the above-identified application, the information listed on the attached form PTO/SB/08A. The order of presentation of the references should not be construed as an indication of the importance of the reference.

Remarks: A copy of each reference, together with a listing on Form PTO/SB/08A, is submitted herewith. Applicants respectfully request that:

1. The Examiner consider completely the cited information, along with any other information, in reaching a determination concerning the patentability of the present claims;
2. The enclosed form PTO/SB/08A be signed by the Examiner to evidence that the cited information has been fully considered by the Patent and Trademark Office during the examination of this application; and
3. The citations for the information be printed on any patent which issues from this application.

By submitting this Information Disclosure Statement, the Applicants make no representation that a search has been performed, of the extent of any search performed, or that more relevant information does not exist.

By submitting this Information Disclosure Statement, the Applicants make no representation that the information cited in the Statement is, or is considered to be, material to patentability as defined in 37 C.F.R. §1.56(b).

By submitting this Information Disclosure Statement, the Applicants make no representation that the information cited in the Statement is, or is considered to be, in fact, prior art as defined in 37 C.F.R. §102.

Notwithstanding any statement by the Applicant, the Examiner is urged to form his own conclusion regarding the relevance of the cited information.

DEPOSIT ACCOUNT 190130 AUTHORIZATION – The Office is hereby authorized to charge the required fee, and any deficiency or credit any overpayment in the fees to the above deposit account, owned by BAE SYSTEMS Information and Electronic Systems Integration Inc. an authorized signator for which is Kevin M. Perkins, V.P. & Company Counsel, and for whom the undersigned are authorized agents.

An early and favorable action is hereby requested.

Respectfully submitted,

/Scott J. Asmus, Reg. No. 42,269/

Cus. No. 42716
Maine & Asmus
PO Box 3445
Nashua, NH 03061-3445
Tel. No. (603) 886-6100, Fax. No. (603) 886-4796
Patents@maineandasmus.com

Scott J. Asmus, Reg. No. 42,269
Andrew P. Cernota, Reg. No. 52,711
Kristina M. Grasso, Reg. No. 39,205
Attorneys/Agents for Applicant



UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
Address: COMMISSIONER FOR PATENTS
P.O. Box 1450
Alexandria, Virginia 22313-1450
www.uspto.gov

APPLICATION NUMBER	PATENT NUMBER	GROUP ART UNIT	FILE WRAPPER LOCATION
11/532,125		2611	



CC000000034049403

Correspondence Address/Fee Address Change

The following fields have been set to Customer Number 22500 on 01/13/2009

- Correspondence Address
- Power of Attorney Address

The address of record for Customer Number 22500 is:

22500
BAE SYSTEMS
PO BOX 868
NASHUA, NH 03061-0868



UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
Address: COMMISSIONER FOR PATENTS
P.O. Box 1450
Alexandria, Virginia 22313-1450
www.uspto.gov

NOTICE OF ALLOWANCE AND FEE(S) DUE

22500 7590 07/30/2009

BAE SYSTEMS
PO BOX 868
NASHUA, NH 03061-0868

EXAMINER

KIM, KEVIN

ART UNIT

PAPER NUMBER

2611

DATE MAILED: 07/30/2009

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
11/532,125	09/15/2006	Mark Lande	20050089-US	2294

TITLE OF INVENTION: COMBINATIONAL HYBRID TURBO-MUD

APPLN. TYPE	SMALL ENTITY	ISSUE FEE DUE	PUBLICATION FEE DUE	PREV. PAID ISSUE FEE	TOTAL FEE(S) DUE	DATE DUE
nonprovisional	NO	\$1510	\$0	\$0	\$1510	10/30/2009

THE APPLICATION IDENTIFIED ABOVE HAS BEEN EXAMINED AND IS ALLOWED FOR ISSUANCE AS A PATENT. PROSECUTION ON THE MERITS IS CLOSED. THIS NOTICE OF ALLOWANCE IS NOT A GRANT OF PATENT RIGHTS. THIS APPLICATION IS SUBJECT TO WITHDRAWAL FROM ISSUE AT THE INITIATIVE OF THE OFFICE OR UPON PETITION BY THE APPLICANT. SEE 37 CFR 1.313 AND MPEP 1308.

THE ISSUE FEE AND PUBLICATION FEE (IF REQUIRED) MUST BE PAID WITHIN THREE MONTHS FROM THE MAILING DATE OF THIS NOTICE OR THIS APPLICATION SHALL BE REGARDED AS ABANDONED. THIS STATUTORY PERIOD CANNOT BE EXTENDED. SEE 35 U.S.C. 151. THE ISSUE FEE DUE INDICATED ABOVE DOES NOT REFLECT A CREDIT FOR ANY PREVIOUSLY PAID ISSUE FEE IN THIS APPLICATION. IF AN ISSUE FEE HAS PREVIOUSLY BEEN PAID IN THIS APPLICATION (AS SHOWN ABOVE), THE RETURN OF PART B OF THIS FORM WILL BE CONSIDERED A REQUEST TO REAPPLY THE PREVIOUSLY PAID ISSUE FEE TOWARD THE ISSUE FEE NOW DUE.

HOW TO REPLY TO THIS NOTICE:

I. Review the SMALL ENTITY status shown above.

If the SMALL ENTITY is shown as YES, verify your current SMALL ENTITY status:

A. If the status is the same, pay the TOTAL FEE(S) DUE shown above.

B. If the status above is to be removed, check box 5b on Part B - Fee(s) Transmittal and pay the PUBLICATION FEE (if required) and twice the amount of the ISSUE FEE shown above, or

If the SMALL ENTITY is shown as NO:

A. Pay TOTAL FEE(S) DUE shown above, or

B. If applicant claimed SMALL ENTITY status before, or is now claiming SMALL ENTITY status, check box 5a on Part B - Fee(s) Transmittal and pay the PUBLICATION FEE (if required) and 1/2 the ISSUE FEE shown above.

II. PART B - FEE(S) TRANSMITTAL, or its equivalent, must be completed and returned to the United States Patent and Trademark Office (USPTO) with your ISSUE FEE and PUBLICATION FEE (if required). If you are charging the fee(s) to your deposit account, section "4b" of Part B - Fee(s) Transmittal should be completed and an extra copy of the form should be submitted. If an equivalent of Part B is filed, a request to reapply a previously paid issue fee must be clearly made, and delays in processing may occur due to the difficulty in recognizing the paper as an equivalent of Part B.

III. All communications regarding this application must give the application number. Please direct all communications prior to issuance to Mail Stop ISSUE FEE unless advised to the contrary.

IMPORTANT REMINDER: Utility patents issuing on applications filed on or after Dec. 12, 1980 may require payment of maintenance fees. It is patentee's responsibility to ensure timely payment of maintenance fees when due.

PART B - FEE(S) TRANSMITTAL

**Complete and send this form, together with applicable fee(s), to: Mail Mail Stop ISSUE FEE
Commissioner for Patents
P.O. Box 1450
Alexandria, Virginia 22313-1450
or Fax (571)-273-2885**

INSTRUCTIONS: This form should be used for transmitting the ISSUE FEE and PUBLICATION FEE (if required). Blocks 1 through 5 should be completed where appropriate. All further correspondence including the Patent, advance orders and notification of maintenance fees will be mailed to the current correspondence address as indicated unless corrected below or directed otherwise in Block 1, by (a) specifying a new correspondence address; and/or (b) indicating a separate "FEE ADDRESS" for maintenance fee notifications.

CURRENT CORRESPONDENCE ADDRESS (Note: Use Block 1 for any change of address)

22500 7590 07/30/2009

BAE SYSTEMS
PO BOX 868
NASHUA, NH 03061-0868

Note: A certificate of mailing can only be used for domestic mailings of the Fee(s) Transmittal. This certificate cannot be used for any other accompanying papers. Each additional paper, such as an assignment or formal drawing, must have its own certificate of mailing or transmission.

Certificate of Mailing or Transmission

I hereby certify that this Fee(s) Transmittal is being deposited with the United States Postal Service with sufficient postage for first class mail in an envelope addressed to the Mail Stop ISSUE FEE address above, or being facsimile transmitted to the USPTO (571) 273-2885, on the date indicated below.

(Depositor's name)
(Signature)
(Date)

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
11/532,125	09/15/2006	Mark Lande	20050089-US	2294

TITLE OF INVENTION: COMBINATIONAL HYBRID TURBO-MUD

APPLN. TYPE	SMALL ENTITY	ISSUE FEE DUE	PUBLICATION FEE DUE	PREV. PAID ISSUE FEE	TOTAL FEE(S) DUE	DATE DUE
nonprovisional	NO	\$1510	\$0	\$0	\$1510	10/30/2009

EXAMINER	ART UNIT	CLASS-SUBCLASS
KIM, KEVIN	2611	375-148000

1. Change of correspondence address or indication of "Fee Address" (37 CFR 1.363).

- ☐ Change of correspondence address (or Change of Correspondence Address form PTO/SB/122) attached.
- ☐ "Fee Address" indication (or "Fee Address" Indication form PTO/SB/47; Rev 03-02 or more recent) attached. **Use of a Customer Number is required.**

2. For printing on the patent front page, list

- (1) the names of up to 3 registered patent attorneys or agents OR, alternatively, 1 _____
- (2) the name of a single firm (having as a member a registered attorney or agent) and the names of up to 2 registered patent attorneys or agents. If no name is listed, no name will be printed. 2 _____
- 3 _____

3. ASSIGNEE NAME AND RESIDENCE DATA TO BE PRINTED ON THE PATENT (print or type)

PLEASE NOTE: Unless an assignee is identified below, no assignee data will appear on the patent. If an assignee is identified below, the document has been filed for recordation as set forth in 37 CFR 3.11. Completion of this form is NOT a substitute for filing an assignment.

(A) NAME OF ASSIGNEE

(B) RESIDENCE: (CITY and STATE OR COUNTRY)

Please check the appropriate assignee category or categories (will not be printed on the patent) : ☐ Individual ☐ Corporation or other private group entity ☐ Government

4a. The following fee(s) are submitted:

- ☐ Issue Fee
- ☐ Publication Fee (No small entity discount permitted)
- ☐ Advance Order - # of Copies _____

4b. Payment of Fee(s): (**Please first reapply any previously paid issue fee shown above**)

- ☐ A check is enclosed.
- ☐ Payment by credit card. Form PTO-2038 is attached.
- ☐ The Director is hereby authorized to charge the required fee(s), any deficiency, or credit any overpayment, to Deposit Account Number _____ (enclose an extra copy of this form).

5. **Change in Entity Status** (from status indicated above)

- ☐ a. Applicant claims SMALL ENTITY status. See 37 CFR 1.27. ☐ b. Applicant is no longer claiming SMALL ENTITY status. See 37 CFR 1.27(g)(2).

NOTE: The Issue Fee and Publication Fee (if required) will not be accepted from anyone other than the applicant; a registered attorney or agent; or the assignee or other party in interest as shown by the records of the United States Patent and Trademark Office.

Authorized Signature _____

Date _____

Typed or printed name _____

Registration No. _____

This collection of information is required by 37 CFR 1.311. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 12 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, Virginia 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, Virginia 22313-1450.

Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it displays a valid OMB control number.



UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
Address: COMMISSIONER FOR PATENTS
P.O. Box 1450
Alexandria, Virginia 22313-1450
www.uspto.gov

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
11/532,125	09/15/2006	Mark Lande	20050089-US	2294
22500	7590	07/30/2009	EXAMINER	
BAE SYSTEMS PO BOX 868 NASHUA, NH 03061-0868			KIM, KEVIN	
			ART UNIT	PAPER NUMBER
			2611	
DATE MAILED: 07/30/2009				

Determination of Patent Term Adjustment under 35 U.S.C. 154 (b)

(application filed on or after May 29, 2000)

The Patent Term Adjustment to date is 623 day(s). If the issue fee is paid on the date that is three months after the mailing date of this notice and the patent issues on the Tuesday before the date that is 28 weeks (six and a half months) after the mailing date of this notice, the Patent Term Adjustment will be 623 day(s).

If a Continued Prosecution Application (CPA) was filed in the above-identified application, the filing date that determines Patent Term Adjustment is the filing date of the most recent CPA.

Applicant will be able to obtain more detailed information by accessing the Patent Application Information Retrieval (PAIR) WEB site (<http://pair.uspto.gov>).

Any questions regarding the Patent Term Extension or Adjustment determination should be directed to the Office of Patent Legal Administration at (571)-272-7702. Questions relating to issue and publication fee payments should be directed to the Customer Service Center of the Office of Patent Publication at 1-(888)-786-0101 or (571)-272-4200.

Notice of Allowability	Application No.	Applicant(s)	
	11/532,125	LANDE, MARK	
	Examiner	Art Unit	
	Kevin Y. Kim	2611	

-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address--

All claims being allowable, PROSECUTION ON THE MERITS IS (OR REMAINS) CLOSED in this application. If not included herewith (or previously mailed), a Notice of Allowance (PTOL-85) or other appropriate communication will be mailed in due course. **THIS NOTICE OF ALLOWABILITY IS NOT A GRANT OF PATENT RIGHTS.** This application is subject to withdrawal from issue at the initiative of the Office or upon petition by the applicant. See 37 CFR 1.313 and MPEP 1308.

1. ☒ This communication is responsive to application filed on September 15, 2006.

2. ☒ The allowed claim(s) is/are 1-20.

3. ☐ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).
a) ☐ All b) ☐ Some* c) ☐ None of the:
1. ☐ Certified copies of the priority documents have been received.
2. ☐ Certified copies of the priority documents have been received in Application No. _____.
3. ☐ Copies of the certified copies of the priority documents have been received in this national stage application from the International Bureau (PCT Rule 17.2(a)).
* Certified copies not received: _____.

Applicant has THREE MONTHS FROM THE "MAILING DATE" of this communication to file a reply complying with the requirements noted below. Failure to timely comply will result in ABANDONMENT of this application.
THIS THREE-MONTH PERIOD IS NOT EXTENDABLE.

4. ☐ A SUBSTITUTE OATH OR DECLARATION must be submitted. Note the attached EXAMINER'S AMENDMENT or NOTICE OF INFORMAL PATENT APPLICATION (PTO-152) which gives reason(s) why the oath or declaration is deficient.

5. ☐ CORRECTED DRAWINGS (as "replacement sheets") must be submitted.
(a) ☐ including changes required by the Notice of Draftsperson's Patent Drawing Review (PTO-948) attached
1) ☐ hereto or 2) ☐ to Paper No./Mail Date _____.
(b) ☐ including changes required by the attached Examiner's Amendment / Comment or in the Office action of Paper No./Mail Date _____.

Identifying indicia such as the application number (see 37 CFR 1.84(c)) should be written on the drawings in the front (not the back) of each sheet. Replacement sheet(s) should be labeled as such in the header according to 37 CFR 1.121(d).

6. ☐ DEPOSIT OF and/or INFORMATION about the deposit of BIOLOGICAL MATERIAL must be submitted. Note the attached Examiner's comment regarding REQUIREMENT FOR THE DEPOSIT OF BIOLOGICAL MATERIAL.

Attachment(s)

1. ☒ Notice of References Cited (PTO-892) 2. ☐ Notice of Draftsperson's Patent Drawing Review (PTO-948) 3. ☒ Information Disclosure Statements (PTO/SB/08), Paper No./Mail Date <u>10/24/06</u> 4. ☐ Examiner's Comment Regarding Requirement for Deposit of Biological Material	5. ☐ Notice of Informal Patent Application 6. ☐ Interview Summary (PTO-413), Paper No./Mail Date _____. 7. ☐ Examiner's Amendment/Comment 8. ☒ Examiner's Statement of Reasons for Allowance 9. ☐ Other _____.
---	---

/Kevin Y Kim/ Primary Examiner, Art Unit 2611	
--	--

DETAILED ACTION

Allowable Subject Matter

1. Claims 1-20 are allowed.
2. The following is an examiner's statement of reasons for allowance: No prior art reference has been found to teach or suggest selecting one of a plurality of multi-user detectors based on a decision criteria .

Any comments considered necessary by applicant must be submitted no later than the payment of the issue fee and, to avoid processing delays, should preferably accompany the issue fee. Such submissions should be clearly labeled "Comments on Statement of Reasons for Allowance."

Conclusion

3. The prior art made of record and not relied upon is considered pertinent to applicant's disclosure.

US patents Nos. 7,110,439;7,340,281;7,133,433 teach a multi-user detector.

Any inquiry concerning this communication or earlier communications from the examiner should be directed to Kevin Y. Kim whose telephone number is 571-272-3039. The examiner can normally be reached on 8AM --5PM M-F.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Shuwang Liu can be reached on 571-272-3036. The fax phone number for the organization where this application or proceeding is assigned is 571-273-8300.

Art Unit: 2611

Information regarding the status of an application may be obtained from the Patent Application Information Retrieval (PAIR) system. Status information for published applications may be obtained from either Private PAIR or Public PAIR. Status information for unpublished applications is available through Private PAIR only. For more information about the PAIR system, see <http://pair-direct.uspto.gov>. Should you have questions on access to the Private PAIR system, contact the Electronic Business Center (EBC) at 866-217-9197 (toll-free). If you would like assistance from a USPTO Customer Service Representative or access to the automated information system, call 800-786-9199 (IN USA OR CANADA) or 571-272-1000.

/Kevin Y Kim/

Primary Examiner, Art Unit 2611

Notice of References Cited	Application/Control No. 11/532,125		Applicant(s)/Patent Under Reexamination LANDE, MARK	
	Examiner Kevin Y. Kim		Art Unit 2611	Page 1 of 1

U.S. PATENT DOCUMENTS

*		Document Number Country Code-Number-Kind Code	Date MM-YYYY	Name	Classification
*	A	US-7,110,439	09-2006	MacLeod, Robert B.	375/147
*	B	US-7,340,281	03-2008	Zeira et al.	455/562.1
*	C	US-7,133,433	11-2006	Jalloul et al.	375/141
	D	US-			
	E	US-			
	F	US-			
	G	US-			
	H	US-			
	I	US-			
	J	US-			
	K	US-			
	L	US-			
	M	US-			

FOREIGN PATENT DOCUMENTS

*		Document Number Country Code-Number-Kind Code	Date MM-YYYY	Country	Name	Classification
	N					
	O					
	P					
	Q					
	R					
	S					
	T					

NON-PATENT DOCUMENTS

*		Include as applicable: Author, Title Date, Publisher, Edition or Volume, Pertinent Pages)
	U	
	V	
	W	
	X	

*A copy of this reference is not being furnished with this Office action. (See MPEP § 707.05(a).)
Dates in MM-YYYY format are publication dates. Classifications may be US or foreign.

<i>Index of Claims</i> 	Application/Control No. 11532125	Applicant(s)/Patent Under Reexamination LANDE, MARK
	Examiner Kevin Y Kim	Art Unit 2611

✓	Rejected	-	Cancelled	N	Non-Elected	A	Appeal
=	Allowed	÷	Restricted	I	Interference	O	Objected

☒ Claims renumbered in the same order as presented by applicant ☐ CPA ☐ T.D. ☐ R.1.47									
CLAIM		DATE							
Final	Original	07/15/2009							
	1	=							
	2	=							
	3	=							
	4	=							
	5	=							
	6	=							
	7	=							
	8	=							
	9	=							
	10	=							
	11	=							
	12	=							
	13	=							
	14	=							
	15	=							
	16	=							
	17	=							
	18	=							
	19	=							
	20	=							

Issue Classification 	Application/Control No. 11532125	Applicant(s)/Patent Under Reexamination LANDE, MARK
	Examiner Kevin Y Kim	Art Unit 2611

ORIGINAL						INTERNATIONAL CLASSIFICATION												
CLASS		SUBCLASS				CLAIMED					NON-CLAIMED							
375		346				H	0	3	D	1 / 04 (2006.01.01)								
CROSS REFERENCE(S)																		
CLASS	SUBCLASS (ONE SUBCLASS PER BLOCK)																	
375	148																	
370	342																	

☒ Claims renumbered in the same order as presented by applicant ☐ CPA ☐ T.D. ☐ R.1.47															
Final	Original	Final	Original	Final	Original	Final	Original	Final	Original	Final	Original	Final	Original	Final	Original
	1		17												
	2		18												
	3		19												
	4		20												
	5														
	6														
	7														
	8														
	9														
	10														
	11														
	12														
	13														
	14														
	15														
	16														

NONE		Total Claims Allowed:	
		20	
(Assistant Examiner)	(Date)		
/Kevin Y Kim/ Primary Examiner.Art Unit 2611	07/15/2009	O.G. Print Claim(s)	O.G. Print Figure
(Primary Examiner)	(Date)	1	2

Search Notes 	Application/Control No. 11532125	Applicant(s)/Patent Under Reexamination LANDE, MARK
	Examiner Kevin Y Kim	Art Unit 2611

SEARCHED			
Class	Subclass	Date	Examiner
375	144,148,341,346	7/15/2009	kim
370	342,441	7/15/2009	kim

SEARCH NOTES		
Search Notes	Date	Examiner
inventor search	7/15/2009	kim
EAST keyword text search	7/15/2009	kim
IEEE Xplore keyword text search	7/15/2009	kim

INTERFERENCE SEARCH			
Class	Subclass	Date	Examiner
see interference search printout		7/15/2009	kim

	/Kevin Y Kim/ Primary Examiner.Art Unit 2611
--	---



UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
 United States Patent and Trademark Office
 Address: COMMISSIONER FOR PATENTS
 P.O. Box 1450
 Alexandria, Virginia 22313-1450
 www.uspto.gov

BIB DATA SHEET

CONFIRMATION NO. 2294

SERIAL NUMBER 11/532,125	FILING or 371(c) DATE 09/15/2006 RULE	CLASS 375	GROUP ART UNIT 2611	ATTORNEY DOCKET NO. 20050089-US		
APPLICANTS Mark Lande, Nashua, NH; ** CONTINUING DATA ***** none;k.k. ** FOREIGN APPLICATIONS ***** none;k.k. ** IF REQUIRED, FOREIGN FILING LICENSE GRANTED **						
Foreign Priority claimed ☐ Yes ☒ No 35 USC 119(a-d) conditions met ☐ Yes ☒ No Verified and /KEVIN KIM/ Acknowledged Examiner's Signature		☐ Met after Allowance Initials	STATE OR COUNTRY NH	SHEETS DRAWINGS 7	TOTAL CLAIMS 20	INDEPENDENT CLAIMS 3
ADDRESS BAE SYSTEMS PO BOX 868 NASHUA, NH 03061-0868 UNITED STATES						
TITLE COMBINATIONAL HYBRID TURBO-MUD						
FILING FEE RECEIVED 1000	FEES: Authority has been given in Paper No. _____ to charge/credit DEPOSIT ACCOUNT No. _____ for following:			☐ All Fees		
				☐ 1.16 Fees (Filing)		
				☐ 1.17 Fees (Processing Ext. of time)		
				☐ 1.18 Fees (Issue)		
				☐ Other _____		
				☐ Credit		

EAST Search History**EAST Search History (Prior Art)**

Ref #	Hits	Search Query	DBs	Default Operator	Plurals	Time Stamp
L4	1015	"multi-user detection"	US-PGPUB; USPAT; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2009/07/15 14:13
L5	375	"multi-user detector"	US-PGPUB; USPAT; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2009/07/15 14:13
L6	1197	L4 or L5	US-PGPUB; USPAT; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2009/07/15 14:13
L7	174	6.ti.	US-PGPUB; USPAT; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2009/07/15 14:14
S36	1015	"multi-user detection"	US-PGPUB; USPAT; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2009/07/15 10:53
S37	375	"multi-user detector"	US-PGPUB; USPAT; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2009/07/15 10:53
S38	1197	S36 or S37	US-PGPUB; USPAT; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2009/07/15 10:53
S39	32822471	@ad<"20060915"	US-PGPUB; USPAT; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2009/07/15 10:54
S40	1047	S38 and S39	US-PGPUB; USPAT; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2009/07/15 10:54

S41	6210220	select\$	US-PGPUB; USPAT; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2009/07/15 10:54
S42	72602	mud	US-PGPUB; USPAT; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2009/07/15 10:54
S43	1372	S41 near5 S42	US-PGPUB; USPAT; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2009/07/15 10:55
S44	18	S40 and S43	US-PGPUB; USPAT; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2009/07/15 10:55
S45	4153128	plurality	US-PGPUB; USPAT; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2009/07/15 10:59
S46	8944	muds	US-PGPUB; USPAT; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2009/07/15 10:59
S47	1	S45 adj S46	US-PGPUB; USPAT; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2009/07/15 10:59
S48	130	"multi-user detectors"	US-PGPUB; USPAT; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2009/07/15 10:59
S49	2	S45 adj S48	US-PGPUB; USPAT; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2009/07/15 10:59
S50	117	S39 and S48	US-PGPUB; USPAT; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2009/07/15 11:01

7/ 15/ 2009 2:29:20 PM

C:\Documents and Settings\kkim2\My Documents\EAST\Workspaces\2182008.wsp

EAST Search History**EAST Search History (Prior Art)**

Ref #	Hits	Search Query	DBs	Default Operator	Plurals	Time Stamp
L1	6006	375/144,148,346,341.ccls.	US-PGPUB; USPAT; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2009/07/15 14:31
L2	5087	370/342,441.ccls.	US-PGPUB; USPAT; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2009/07/15 14:32
L3	10739	1 or 2	US-PGPUB; USPAT; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2009/07/15 14:33
L4	1254	multi-user adj detect\$	US-PGPUB; USPAT; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2009/07/15 14:33
L5	338	3 and 4	US-PGPUB; USPAT; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2009/07/15 14:33
L6	72602	mud	US-PGPUB; USPAT; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2009/07/15 14:34
L7	453669	complexity	US-PGPUB; USPAT; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2009/07/15 14:34
L8	172	6 with 7	US-PGPUB; USPAT; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2009/07/15 14:34
L9	43	5 and 8	US-PGPUB; USPAT; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2009/07/15 14:34

L10	32822471	@ad<"20060915"	US-PGPUB; USPAT; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2009/07/15 14:34
L11	39	9 and 10	US-PGPUB; USPAT; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2009/07/15 14:35
L12	484327	subtract\$	US-PGPUB; USPAT; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2009/07/15 14:38
L13	112	4 same 12	US-PGPUB; USPAT; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2009/07/15 14:38
L14	111	10 and 13	US-PGPUB; USPAT; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2009/07/15 14:38
L15	158	window adj bits	US-PGPUB; USPAT; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2009/07/15 14:40
L16	2	4 and 15	US-PGPUB; USPAT; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2009/07/15 14:40
L17	748641	estimat\$	US-PGPUB; USPAT; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2009/07/15 14:42
L18	29	4 with 17 with bits	US-PGPUB; USPAT; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2009/07/15 14:43
L19	26	10 and 18	US-PGPUB; USPAT; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2009/07/15 14:43
L20	189	4.ti.	US-PGPUB; USPAT; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2009/07/15 14:47

L21	555348	bits	US-PGPUB; USPAT; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2009/07/15 14:47
L22	44	4 with 21	US-PGPUB; USPAT; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2009/07/15 14:48
L23	19	20 and 22	US-PGPUB; USPAT; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2009/07/15 14:48
L24	19	10 and 23	US-PGPUB; USPAT; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2009/07/15 14:48

7/ 15/ 2009 2:51:59 PM

EAST Search History**EAST Search History (Interference)**

Ref #	Hits	Search Query	DBs	Default Operator	Plurals	Time Stamp
L1	75	(multi-user adj detect \$).clm.	USPAT; UPAD	OR	OFF	2009/07/15 14:52

7/ 15/ 2009 2:55:37 PM

Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it contains a valid OMB control number.

INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Not for submission under 37 CFR 1.99)	Application Number		11532125
	Filing Date		2006-09-15
	First Named Inventor	LANDE, Mark	
	Art Unit	2611	
	Examiner Name		
	Attorney Docket Number	20050089-US	

U.S. PATENTS							Remove
Examiner Initial*	Cite No	Patent Number	Kind Code ¹	Issue Date	Name of Patentee or Applicant of cited Document	Pages, Columns, Lines where Relevant Passages or Relevant Figures Appear	
	1	5506861		1996-04-09	Bottomley		
	2	5563897		1996-10-08	Pyndiah et al.		
	3	6122269		2000-09-19	Wales		
	4	6151370		2000-11-21	Wei		
	5	6167022		2000-12-26	Ishida et al.		
	6	6704376	B2	2004-03-09	Mills et al.		
	7	6898248	B1	2005-05-24	Elgamal et al.		
	8	6182261	B1	2001-01-30	Haller et al.		
If you wish to add additional U.S. Patent citation information please click the Add button.							Add

INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Not for submission under 37 CFR 1.99)	Application Number		11532125	11532125 - GAU: 2611
	Filing Date		2006-09-15	
	First Named Inventor	LANDE, Mark		
	Art Unit	2611		
	Examiner Name			
	Attorney Docket Number	20050089-US		

U.S.PATENT APPLICATION PUBLICATIONS							Remove
Examiner Initial*	Cite No	Publication Number	Kind Code ¹	Publication Date	Name of Patentee or Applicant of cited Document	Pages,Columns,Lines where Relevant Passages or Relevant Figures Appear	
	1	20030187928	A1	2003-10-02	MacLeod et al.		
	2	20040022336	A1	2004-02-05	Yu et al.		
	3	20050018793	A1	2005-01-27	Learned		

If you wish to add additional U.S. Published Application citation information please click the Add button.

Add

FOREIGN PATENT DOCUMENTS								Remove
Examiner Initial*	Cite No	Foreign Document Number ³	Country Code ² j	Kind Code ⁴	Publication Date	Name of Patentee or Applicant of cited Document	Pages,Columns,Lines where Relevant Passages or Relevant Figures Appear	T ⁵
	1							☐

If you wish to add additional Foreign Patent Document citation information please click the Add button.

Add

NON-PATENT LITERATURE DOCUMENTS				Remove
Examiner Initials*	Cite No	Include name of the author (in CAPITAL LETTERS), title of the article (when appropriate), title of the item (book, magazine, journal, serial, symposium, catalog, etc), date, pages(s), volume-issue number(s), publisher, city and/or country where published.	T ⁵	
	1	POTTIE, Gregory J et al., "A Comparison of Reduced Complexity Decoding Algorithms for Trellis Codes", IEEE on Selected Areas in Communications, December 1989, pp. 1369-1380, Vol. 7, No. 9.	☐	
	2	BERROU, Claude et al., "Near Optimum Error Correcting Coding and Decoding: Turbo-Codes", IEEE Trans. on Communications, October 1996, pp. 1261-1271, Vol. 44, No. 10.	☐	

INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Not for submission under 37 CFR 1.99)	Application Number		11532125 11532125 - GAU: 2611
	Filing Date		2006-09-15
	First Named Inventor	LANDE, Mark	
	Art Unit	2611	
	Examiner Name		
	Attorney Docket Number	20050089-US	

3	BERROU, Claude et al., "Near Shannon Limit Error-Correcting Coding and Decoding: Turbo Codes(1)", IEEE, 1993, pp. 1064-1070.	☐
4	DUANYI, Wang et al., "Low-Complexity MAP Decoding for Turbo Codes", Vehicular Technology Conference, 2000, pp. 1035-1039, Princeton University, Princeton NJ.	☐
5	HERZOG, Rupert et al., "Iterative Decoding and Despreading Improves CDMA-Systems Using M-ary Orthogonal Modulation and FEC", IEEE, 1997, pp. 909-913.	☐
6	DAS, Suman et al., "Computationally Efficient Iterative Multiuser Detection and Decoding", Asilomar, 1998, pp. 631-634, Department of Electrical and Computer Engineering, Rice University, Houston Texas.	☐
7	WANG, Xiaodong et al., "Iterative (Turbo) Soft Interference Cancellation and Decoding for Coded CDMA", IEEE Trans. on Communications, July 1999, pp. 1046-1061, Vol. 47, No. 7.	☐
8	POOR, Vincent, "Turbo Multiuser Detection: An Overview", Department of Electrical Engineering, IEEE 6th International Symposium on Spread-Spectrum Tech. & Appliances, September 2000, pp. 583-587, Princeton University, Princeton NJ.	☐
9	ALEXANDER, Paul et al., "Iterative Multiuser Interference Reduction: Turbo CDMA", IEEE Transactions on Communications, July 1999, pp. 1008-1014, Vol. 47, No. 7.	☐
10	HAGENAUER, Joachim et al., "A Viterbi Algorithm with Soft-Detection Outputs and its Applications", IEEE, 1989, pp. 1680-1686.	☐
11	ROBERTSON, Patrick, "A Comparison of Optimal and Sub-Optimal MAP Decoding Algorithms Operating in the Log Domain", IEEE, 1995, pp. 1009-1013.	☐
12	VERDU, S., "Minimum Probability of Error for Asynchronous Gaussian Multiple-Access Channels", IEEE Transactions on Information Theory, January 1986, pp. 85-96, Vol. IT-32, No. 1.	☐
13	LUPAS, Ruxandra et al., "Linear Multiuser Detectors for Synchronous Code-Division Multiple-Access Channels", IEEE Transactions on Information Theory, January 1989, pp. 123-136, Vol. 35, No. 1.	☐

INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Not for submission under 37 CFR 1.99)	Application Number		11532125	11532125 - GAU: 2611
	Filing Date		2006-09-15	
	First Named Inventor	LANDE, Mark		
	Art Unit	2611		
	Examiner Name			
	Attorney Docket Number	20050089-US		

14	WEI, Lei et al., "Synchronous DS-SSMA System with Improved Decorrelating Decision-Feedback Multiuser Detection", IEEE Transactions on Vehicular Technology, August 1994, pp. 767-772, Vol. 43, No. 3.	☐
15	VARANASI, Mahesh K. et al., "Near-Optimum Detection in Synchronous Code-Division Multiple-Access Systems", IEEE Transactions on Communications, May 1991, pp. 725-736, Vol. 39, No. 5.	☐
16	DUEL-HALLEN, Alexandra, "Decorrelating Decision-Feedback Multiuser Detector for Synchronous Code-Division Multiple-Access Channel", IEEE Transactions on Communications, February 1993, pp. 285-290, Vol. 41, No. 2.	☐
17	LUPAS, Ruxandra et al., "Near-Far Resistance of Multiuser Detectors in Asynchronous Channels", IEEE Transactions on Communications, April 1990, pp. 496-508, Vol. 38, No. 4.	☐

If you wish to add additional non-patent literature document citation information please click the Add button

EXAMINER SIGNATURE

Examiner Signature	/Kevin Kim/	Date Considered	07/15/2009
--------------------	-------------	-----------------	------------

*EXAMINER: Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through a citation if not in conformance and not considered. Include copy of this form with next communication to applicant.

¹ See Kind Codes of USPTO Patent Documents at www.USPTO.GOV or MPEP 901.04. ² Enter office that issued the document, by the two-letter code (WIPO Standard ST.3). ³ For Japanese patent documents, the indication of the year of the reign of the Emperor must precede the serial number of the patent document. ⁴ Kind of document by the appropriate symbols as indicated on the document under WIPO Standard ST.16 if possible. ⁵ Applicant is to place a check mark here if English language translation is attached.



UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
Address: COMMISSIONER FOR PATENTS
P.O. Box 1450
Alexandria, Virginia 22313-1450
www.uspto.gov

APPLICATION NUMBER	FILING OR 371(C) DATE	FIRST NAMED APPLICANT	ATTY. DOCKET NO./TITLE
11/532,125	09/15/2006	Mark Lande	20050089-US

CONFIRMATION NO. 2294

NEW OR REVISED PPD NOTICE

22500
BAE SYSTEMS
PO BOX 868
NASHUA, NH 03061-0868



NOTICE OF NEW OR REVISED PROJECTED PUBLICATION DATE

The above-identified application has a new or revised projected publication date. The current projected publication date for this application is 11/05/2009. If this is a new projected publication date (there was no previous projected publication date), the application has been cleared by Licensing & Review or a secrecy order has been rescinded and the application is now in the publication queue.

If this is a revised projected publication date (one that is different from a previously communicated projected publication date), the publication date has been revised due to processing delays in the USPTO or the abandonment and subsequent revival of an application. The application is anticipated to be published on a date that is more than six weeks different from the originally-projected publication date.

More detailed publication information is available through the private side of Patent Application Information Retrieval (PAIR) System. The direct link to access PAIR is currently <http://pair.uspto.gov>. Further assistance in electronically accessing the publication, or about PAIR, is available by calling the Patent Electronic Business Center at 1-866-217-9197.

Questions relating to this Notice should be directed to the Office of Data Management, Application Assistance Unit at (571) 272-4000, or (571) 272-4200, or 1-888-786-0101.

PART B - FEE(S) TRANSMITTAL

Complete and send this form, together with applicable fee(s), to: **Mail** Mail Stop ISSUE FEE
Commissioner for Patents
P.O. Box 1450
Alexandria, Virginia 22313-1450
or Fax (571)-273-2885

INSTRUCTIONS: This form should be used for transmitting the ISSUE FEE and PUBLICATION FEE (if required). Blocks 1 through 5 should be completed where appropriate. All further correspondence including the Patent, advance orders and notification of maintenance fees will be mailed to the current correspondence address as indicated unless corrected below or directed otherwise in Block 1, by (a) specifying a new correspondence address; and/or (b) indicating a separate "FEE ADDRESS" for maintenance fee notifications.

CURRENT CORRESPONDENCE ADDRESS (Note: Use Block 1 for any change of address)

22500 7590 07/30/2009

BAE SYSTEMS
 PO BOX 868
 NASHUA, NH 03061-0868

Note: A certificate of mailing can only be used for domestic mailings of the Fee(s) Transmittal. This certificate cannot be used for any other accompanying papers. Each additional paper, such as an assignment or formal drawing, must have its own certificate of mailing or transmission.

Certificate of Mailing or Transmission

I hereby certify that this Fee(s) Transmittal is being deposited with the United States Postal Service with sufficient postage for first class mail in an envelope addressed to the Mail Stop ISSUE FEE address above, or being facsimile transmitted to the USPTO (571) 273-2885, on the date indicated below.

(Depositor's name)
(Signature)
(Date)

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
11/532,125	09/15/2006	Mark Lande	20050089-US	2294

TITLE OF INVENTION: COMBINATIONAL HYBRID TURBO-MUD

APPLN. TYPE	SMALL ENTITY	ISSUE FEE DUE	PUBLICATION FEE DUE	PREV. PAID ISSUE FEE	TOTAL FEE(S) DUE	DATE DUE
nonprovisional	NO	\$1510	\$0	\$0	\$1510	10/30/2009
EXAMINER	ART UNIT	CLASS-SUBCLASS				
KIM, KEVIN	2611	375-148000				

1. Change of correspondence address or indication of "Fee Address" (37 CFR 1.363).

- ☐ Change of correspondence address (or Change of Correspondence Address form PTO/SB/122) attached.
- ☐ "Fee Address" indication (or "Fee Address" Indication form PTO/SB/47; Rev 03-02 or more recent) attached. **Use of a Customer Number is required.**

2. For printing on the patent front page, list

- (1) the names of up to 3 registered patent attorneys or agents OR, alternatively,
- (2) the name of a single firm (having as a member a registered attorney or agent) and the names of up to 2 registered patent attorneys or agents. If no name is listed, no name will be printed.

1 Vern Maine & Associates

2

3

3. ASSIGNEE NAME AND RESIDENCE DATA TO BE PRINTED ON THE PATENT (print or type)

PLEASE NOTE: Unless an assignee is identified below, no assignee data will appear on the patent. If an assignee is identified below, the document has been filed for recordation as set forth in 37 CFR 3.111. Completion of this form is NOT a substitute for filing an assignment.

(A) NAME OF ASSIGNEE

(B) RESIDENCE: (CITY and STATE OR COUNTRY)

BAE Systems Information and Electronic Systems Integration Inc.

Nashua, NH

Please check the appropriate assignee category or categories (will not be printed on the patent): ☐ Individual ☒ Corporation or other private group entity ☐ Government

4a. The following fee(s) are submitted:

- ☒ Issue Fee
- ☐ Publication Fee (No small entity discount permitted)
- ☐ Advance Order - # of Copies

4b. Payment of Fee(s): (Please first reapply any previously paid issue fee shown above)

- ☐ A check is enclosed.
- ☐ Payment by credit card. Form PTO-2038 is attached.
- ☒ The Director is hereby authorized to charge the required fee(s), any deficiency, or credit any overpayment, to Deposit Account Number 190130 (enclose an extra copy of this form).

5. Change in Entity Status (from status indicated above)

- ☐ a. Applicant claims SMALL ENTITY status. See 37 CFR 1.27. ☐ b. Applicant is no longer claiming SMALL ENTITY status. See 37 CFR 1.27(g)(2).

NOTE: The Issue Fee and Publication Fee (if required) will not be accepted from anyone other than the applicant; a registered attorney or agent, or the assignee or other party in interest as shown by the records of the United States Patent and Trademark Office.

Authorized Signature

Daniel J. Long

Date

8/10/07

Typed or printed name

Daniel J. Long

Registration No.

29,404

This collection of information is required by 37 CFR 1.311. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 12 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, Virginia 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, Virginia 22313-1450.

Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it displays a valid OMB control number.

Electronic Patent Application Fee Transmittal				
Application Number:		11532125		
Filing Date:		15-Sep-2006		
Title of Invention:		COMBINATIONAL HYBRID TURBO-MUD		
First Named Inventor/Applicant Name:		Mark Lande		
Filer:		Daniel J. Long/Nancy Young		
Attorney Docket Number:		20050089-US		
Filed as Large Entity				
Utility under 35 USC 111(a) Filing Fees				
Description	Fee Code	Quantity	Amount	Sub-Total in USD(\$)
Basic Filing:				
Pages:				
Claims:				
Miscellaneous-Filing:				
Petition:				
Patent-Appeals-and-Interference:				
Post-Allowance-and-Post-Issuance:				
Utility Appl issue fee	1501	1	1510	1510
Extension-of-Time:				

Description	Fee Code	Quantity	Amount	Sub-Total in USD(\$)
Miscellaneous:				
Total in USD (\$)				1510

Electronic Acknowledgement Receipt	
EFS ID:	5854375
Application Number:	11532125
International Application Number:	
Confirmation Number:	2294
Title of Invention:	COMBINATIONAL HYBRID TURBO-MUD
First Named Inventor/Applicant Name:	Mark Lande
Customer Number:	22500
Filer:	Daniel J. Long/Nancy Young
Filer Authorized By:	Daniel J. Long
Attorney Docket Number:	20050089-US
Receipt Date:	10-AUG-2009
Filing Date:	15-SEP-2006
Time Stamp:	09:36:03
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	yes
Payment Type	Deposit Account
Payment was successfully received in RAM	\$1510
RAM confirmation Number	6045
Deposit Account	190130
Authorized User	

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
-----------------	----------------------	-----------	-------------------------------------	------------------	------------------

1	Issue Fee Payment (PTO-85B)	20050089-IssueFee.pdf	682224 0ed840747f1673961b42b841b61d4fd637bb69b8	no	1
Warnings:					
Information:					
2	Fee Worksheet (PTO-875)	fee-info.pdf	29945 c000fa9fc4773c55731d3e1c22d1d4573ed1ce4	no	2
Warnings:					
Information:					
Total Files Size (in bytes):			712169		
This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503. <u>New Applications Under 35 U.S.C. 111</u> If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application. <u>National Stage of an International Application under 35 U.S.C. 371</u> If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course. <u>New International Application Filed with the USPTO as a Receiving Office</u> If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.					



UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
Address: COMMISSIONER FOR PATENTS
P. O. Box 1450
Alexandria, Virginia 22313-1450
www.uspto.gov

APPLICATION NO.	ISSUE DATE	PATENT NO.	ATTORNEY DOCKET NO.	CONFIRMATION NO.
11/532,125	09/22/2009	7593492	20050089-US	2294
22500	7590	09/02/2009		
BAE SYSTEMS PO BOX 868 NASHUA, NH 03061-0868				

ISSUE NOTIFICATION

The projected patent number and issue date are specified above.

Determination of Patent Term Adjustment under 35 U.S.C. 154 (b) (application filed on or after May 29, 2000)

The Patent Term Adjustment is 623 day(s). Any patent to issue from the above-identified application will include an indication of the adjustment on the front page.

If a Continued Prosecution Application (CPA) was filed in the above-identified application, the filing date that determines Patent Term Adjustment is the filing date of the most recent CPA.

Applicant will be able to obtain more detailed information by accessing the Patent Application Information Retrieval (PAIR) WEB site (<http://pair.uspto.gov>).

Any questions regarding the Patent Term Extension or Adjustment determination should be directed to the Office of Patent Legal Administration at (571)-272-7702. Questions relating to issue and publication fee payments should be directed to the Customer Service Center of the Office of Patent Publication at (571)-272-4200.

APPLICANT(s) (Please see PAIR WEB site <http://pair.uspto.gov> for additional applicants):

Mark Lande, Nashua, NH;

POWER OF ATTORNEY FOR PATENT APPLICATIONS

Under CFR § 3.73(b), Collision Technology, LLC, a corporation, hereby certifies that it is the Assignee of the entire right, title, and interest in and to the patent applications listed below. Each of the patent applications listed below is assigned to Collision Technology, LLC. As required by 37 CFR 3.73(b)(1)(i), the documentary evidence of the chain of title from the original owner to the Assignee was submitted for recordation pursuant to 37 CFR 3.11 as shown in the Reel/Frame numbers listed below.

Filing Date	Application Serial No.; Patent No. (if issued)	Title	Reel/Frame
10/03/2003	10/678,203; 6,831,574	MULTI-TURBO MULTI- USER DETECTOR	014073/0269 026190/0812
04/05/2004	10/818,536; 6,967,598	REDUCED COMPLEXITY MULTI-TURBO MULTI- USER DETECTOR	014525/0140 026190/0812
03/24/2005	10/529,019; 7,599,346	BANDWIDTH- EFFICIENT WIRELESS NETWORK MODEM	016520/0107 026190/0812 026193/0661
08/27/2009	12/548,502	BANDWIDTH EFFICIENT WIRELESS NETWORK MODEM	026190/0812
02/03/2004	10/486,004; 7,486,722	BANDWIDTH EFFICIENT CABLE NETWORK MODEM	013771/0874 014405/0749 026190/0812 026193/0661
02/11/2004	10/486,871; 7,245,673	WINDOWED MULTIUSER DETECTION	013816/0233 015656/0249 026190/0812 026193/0661
12/21/2004	10/497,556; 7,126,533	DIRECTION-FINDING FOR MULTIPLE COCHANNEL SOURCES	014737/0931 013824/0323 026190/0812 026193/0661
04/19/2005	10/531,772; 7,463,703	JOINT SYMBOL, AMPLITUDE, AND RATE ESTIMATOR	015999/0543 026190/0812 026193/0661
10/15/2008	12/251,571; 7,590,203	JOINT SYMBOL, AMPLITUDE, AND RATE ESTIMATOR	021690/0566 026190/0812
10/15/2008	12/251,575; 7,583,757	JOINT SYMBOL, AMPLITUDE, AND RATE ESTIMATOR	021690/0608 026190/0812
06/25/2009	12/491,332; 7,920,651	JOINT SYMBOL, AMPLITUDE, AND RATE	022879/0419 026190/0812

		ESTIMATOR	
12/23/2003	10/482,599; 7,428,261	CROSS-SYSTEM INTERFERENCE CANCELLATION FOR MULTICARRIER CDMA AND OFDM	013823/0522 014271/0189 026190/0812 026193/0661
12/01/2005	11/291,883; 7,593,473	TREE STRUCTURED MULTICARRIER MULTIPLE ACCESS SYSTEMS	016887/0516 026190/0812
12/01/2005	11/292,233; 7,817,754	M-ALGORITHM WITH PRIORITIZED USER ORDERING	017098/0162 026190/0812
04/10/2006	11/400,922; 7,783,110	SEMICOHERENT CHANNEL ESTIMATOR	017623/0177 026190/0812
08/10/2006	11/463,877; 7,613,228	M-ALGORITHM MULTIUSER DETECTOR WITH CORRELATION BASED PRUNING	018151/0479 026190/0812
09/15/2006	11/532,125; 7,593,492	COMBINATIONAL HYBRID TURBO-MUD	018272/0171 026190/0812
08/12/2009	12/539,691	METHOD FOR SIMULTANEOUS DETECTION OF A PLURALITY OF RFID TAGS USING MULTIUSER DETECTION	023099/0858 026190/0812
05/13/2010	12/742,686	MEDIA ACCESS CONTROL PROTOCOL FOR MULTIUSER DETECTION ENABLED AD-HOC WIRELESS COMMUNICATIONS	025578/0117 024673/0287 026190/0812
07/24/2003	10/626,146; 7,218,690	HYBRID TURBO-MUD FOR MULTIPLE ACCESS SYSTEMS	013859/0734 026190/0812
04/11/2002	10/120,955; 6,947,506	METHOD AND APPARATUS FOR IMPROVED TURBO MULTIUSER DETECTOR	013095/0631 026190/0812
01/23/2002	10/055,155; 6,839,390	VOTING SYSTEM FOR IMPROVING THE PERFORMANCE OF SINGLE-USER	012540/0669 024907/0140 026190/0812

		DECODERS WITHIN AN ITERATIVE MULTI- USER DETECTION SYSTEM	
11/12/2004	10/987,140; 7,350,136	VOTING SYSTEM FOR IMPROVING THE PERFORMANCE OF SINGLE-USER DECODERS WITHIN AN ITERATIVE MULTI- USER DETECTION SYSTEM	026190/0812
07/29/2002	10/208,409; 6,704,376	POWER AND CONFIDENCE ORDERED LOW COMPLEXITY SOFT TURBOMUD WITH VOTING SYSTEM	013020/0053 026190/0812
06/08/2004	10/863,081; 7,092,464	MULTIUSER DETECTION WITH TARGETED ERROR CORRECTION CODING	014778/0014 026190/0812
03/25/2002	10/105,918; 7,110,439	SYSTEM FOR DECREASING PROCESSING TIME IN AN ITERATIVE MULTI- USER DETECTOR SYSTEM	012744/0987 026190/0812
04/25/2003	10/423,695; 7,190,747	FREQUENCY MISMATCH COMPENSATION FOR MULTIUSER DETECTION	013676/0030 026190/0812
04/25/2003	10/423,740; 7,092,452	CO-CHANNEL INTERFERENCE RECEIVER	013674/0904 026190/0812
07/29/2002	10/207,490; 7,190,743	METHOD AND APPARATUS FOR OPTIMIZING TREE PRUNING IN A MULTIUSER DETECTOR	013198/0060 026190/0812
04/16/2003	10/414,738; 7,269,223	SYSTEM AND METHOD FOR INCREASING THROUGHPUT IN A MULTIUSER DETECTION BASED MULTIPLE ACCESS	013633/0069 026190/0812

		COMMUNICATIONS SYSTEM	
02/14/2005	11/057,479; 7,724,851	RECEIVER WITH MULTIPLE COLLECTORS IN A MULTIPLE USER DETECTION SYSTEM	016000/0309 026190/0812
04/29/2002	10/134,330; 6,981,203	METHOD AND APPARATUS FOR RANDOM SHUFFLED TURBO MULTIUSER DETECTOR	012877/0237 013129/0802 026190/0812
04/25/2003	10/423,655; 7,218,665	DEFERRED DECORRELATING DECISION-FEEDBACK DETECTOR FOR SUPERSATURATED COMMUNICATIONS	013633/0393 025710/0043 026190/0812
04/24/2003	10/422,340; 6,954,482	SOFT-DECISION TRELLIS-CODED DIFFERENTIAL FREQUENCY-HOPPED SPREAD SPECTRUM (DFHSS)	013643/0771 026190/0812
04/22/2005	10/482,598; 6,999,498	MULTIUSER DETECTION AIDED MULTIPLE ACCESS DIFFERENTIAL FREQUENCY-HOPPED SPREAD SPECTRUM	013904/0597 014293/0674 026190/0812 026193/0661
04/19/2004	10/827,462; 7,376,171	MULTIUSER DETECTION AIDED MULTIPLE ACCESS DIFFERENTIAL M-ARY CODING APPLICATIONS	014602/0733 026190/0812
09/10/2003	10/659,567; 7,236,546	PIPELINED TURBO MULTIUSER DETECTION	014002/0447 026190/0812
08/07/2001	09/923,709; 7,058,422	METHOD FOR OVERUSING FREQUENCIES TO PERMIT SIMULTANEOUS TRANSMISSION OF SIGNALS FROM TWO OR MORE USERS ON THE	012100/0995 026190/0812

		SAME FREQUENCY AND TIME SLOT	
08/31/2001	09/943,770; 6,947,505	SYSTEM FOR PARAMETER ESTIMATION AND TRACKING OF INTERFERING DIGITALLY MODULATED SIGNALS	012151/0553 026190/0812
04/16/2003	10/414,784; 6,985,699	EFFICIENT AND OPTIMAL CHANNEL ENCODING AND CHANNEL DECODING IN A MULTIPLE ACCESS COMMUNICATIONS SYSTEM	013633/0018 026190/0812
04/18/2002	10/125,241; 7,233,620	BANDWIDTH-EFFICIENT WIRELESS NETWORK MODEM	012670/0320 026190/0812
06/20/2002	10/176,011; 7,200,103	REDUCED ALGORITHM RECEIVER	013191/0058 026190/0812
06/20/2002	10/175,693; 7,139,334	COOPERATIVE CODE-ENHANCED MULTI-USER COMMUNICATIONS SYSTEM	013192/0370 013194/0865 026190/0812
08/26/2002	10/228,787; 6,947,502	PARAMETER ESTIMATOR FOR A MULTIUSER DETECTION RECEIVER	013198/0089 026190/0812
09/20/2002	10/251,187; 6,826,140	MULTICHANNEL DIGITAL RECORDING SYSTEM WITH MULTI-USER DETECTION	013147/0391 026190/0812
06/30/2004	10/497,557; 7,126,890	MULTITRACK READBACK AND MULTIUSER DETECTION FOR DISK DRIVES	014764/0397 014052/0594 026190/0812 026193/0661
08/27/2010	12/869,875	QR-RLS ADAPTIVE DIGITAL FILTER WITH 18-BIT PIPELINE ARCHITECTURE	024974/0911 026190/0812 026193/0661
04/20/2011	13/090,435	DISTRIBUTED SCHEDULER DESIGN FOR MULTIUSER	026155/0754 026190/0812 026193/0661

		DETECTION ENABLED WIRELESS MOBILE AD HOC NETWORKS	
01/31/2011	13/017,819	MULTIUSER DETECTION ENABLED MEDIUM ACCESS CONTROLE IN MOBILE AD HOC NETWORKS	026126/0450 026190/0812 026193/0661
02/23/2011	12/932,318	POWER AWARE SCHEDULING AND POWER CONTROL TECHNIQUES FOR MULTIUSER DETECTION ENABLED WIRELESS AD-HOC NETWORKS	025895/0099 026190/0812 026193/0661

The undersigned, acting as the Assignee, hereby revokes all prior powers of attorney, if applicable, and appoints the practitioners associated with the customer number 79683 as my/our attorney(s) or agent(s) to prosecute the patent(s) and/or patent application(s) and transact all business in the United States Patent and Trademark Office connected therewith.

By:

Jared Fry

Member, Collision Technology, LLC

Date:

8/13/2011

Electronic Acknowledgement Receipt	
EFS ID:	10732424
Application Number:	11532125
International Application Number:	
Confirmation Number:	2294
Title of Invention:	COMBINATIONAL HYBRID TURBO-MUD
First Named Inventor/Applicant Name:	Mark Lande
Customer Number:	22500
Filer:	Justin Robert Nifong
Filer Authorized By:	
Attorney Docket Number:	20050089-US
Receipt Date:	15-AUG-2011
Filing Date:	15-SEP-2006
Time Stamp:	08:12:55
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment		no			
File Listing:					
Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1	Power of Attorney	POA_Collision_OliveLawGroup_20110812.pdf	3476082	no	6
			a15fd5bbebf4103df873fa8db61954b90f35cfba		
Warnings:					
Information:					

Total Files Size (in bytes):	3476082
This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503. <u>New Applications Under 35 U.S.C. 111</u> If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application. <u>National Stage of an International Application under 35 U.S.C. 371</u> If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course. <u>New International Application Filed with the USPTO as a Receiving Office</u> If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.	



UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
Address: COMMISSIONER FOR PATENTS
P.O. Box 1450
Alexandria, Virginia 22313-1450
www.uspto.gov

APPLICATION NUMBER	FILING OR 371(C) DATE	FIRST NAMED APPLICANT	ATTY. DOCKET NO./TITLE
11/532,125	09/15/2006	Mark Lande	20050089-US

CONFIRMATION NO. 2294

POA ACCEPTANCE LETTER

79683
OLIVE LAW GROUP, PLLC
125 EDINBURGH SOUTH DRIVE, SUITE 100
CARY, NC 27511



OC000000049416042

Date Mailed: 08/24/2011

NOTICE OF ACCEPTANCE OF POWER OF ATTORNEY

This is in response to the Power of Attorney filed 08/15/2011.

The Power of Attorney in this application is accepted. Correspondence in this application will be mailed to the above address as provided by 37 CFR 1.33.

/gbien-aime/

Office of Data Management, Application Assistance Unit (571) 272-4000, or (571) 272-4200, or 1-888-786-0101



UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
Address: COMMISSIONER FOR PATENTS
P.O. Box 1450
Alexandria, Virginia 22313-1450
www.uspto.gov

APPLICATION NUMBER	FILING OR 371(C) DATE	FIRST NAMED APPLICANT	ATTY. DOCKET NO./TITLE
11/532,125	09/15/2006	Mark Lande	20050089-US

CONFIRMATION NO. 2294

POWER OF ATTORNEY NOTICE



OC000000049416030

22500
BAE SYSTEMS
PO BOX 868
NHQ1-719
NASHUA, NH 03061-0868

Date Mailed: 08/24/2011

NOTICE REGARDING CHANGE OF POWER OF ATTORNEY

This is in response to the Power of Attorney filed 08/15/2011.

- The Power of Attorney to you in this application has been revoked by the assignee who has intervened as provided by 37 CFR 3.71. Future correspondence will be mailed to the new address of record(37 CFR 1.33).

/gbien-aime/

Office of Data Management, Application Assistance Unit (571) 272-4000, or (571) 272-4200, or 1-888-786-0101

Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it displays a valid OMB control number.

POWER OF ATTORNEY TO PROSECUTE APPLICATIONS BEFORE THE USPTO

I hereby revoke all previous powers of attorney given in the application identified in the attached statement under 37 CFR 3.73(b).

I hereby appoint:



Practitioners associated with the Customer Number:

114420

OR



Practitioner(s) named below (if more than ten patent practitioners are to be named, then a customer number must be used):

Name	Registration Number	Name	Registration Number

as attorney(s) or agent(s) to represent the undersigned before the United States Patent and Trademark Office (USPTO) in connection with any and all patent applications assigned only to the undersigned according to the USPTO assignment records or assignment documents attached to this form in accordance with 37 CFR 3.73(b).

Please change the correspondence address for the application identified in the attached statement under 37 CFR 3.73(b) to:



The address associated with Customer Number:

114420

OR

☐ Firm or Individual Name			
Address			
City	State	Zip	
Country			
Telephone	Email		

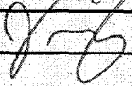
Assignee Name and Address:

Collision Communications, Inc.
20 Depot Street, Suite 2A
Peterborough, NH 03458

A copy of this form, together with a statement under 37 CFR 3.73(b) (Form PTO/SB/96 or equivalent) is required to be filed in each application in which this form is used. The statement under 37 CFR 3.73(b) may be completed by one of the practitioners appointed in this form if the appointed practitioner is authorized to act on behalf of the assignee, and must identify the application in which this Power of Attorney is to be filed.

SIGNATURE of Assignee of Record

The individual whose signature and title is supplied below is authorized to act on behalf of the assignee.

Signature		Date	4/10/2013
Name	Jared Fry	Telephone	(857) 222-0690
Title	Co-Chairman, Collision Communications, Inc.		

This collection of information is required by 37 CFR 1.31, 1.32 and 1.33. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.11 and 1.14. This collection is estimated to take 3 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.

If you need assistance in completing the form, call 1-800-PTO-9199 and select option 2.

Electronic Acknowledgement Receipt	
EFS ID:	16041097
Application Number:	11532125
International Application Number:	
Confirmation Number:	2294
Title of Invention:	COMBINATIONAL HYBRID TURBO-MUD
First Named Inventor/Applicant Name:	Mark Lande
Customer Number:	79683
Filer:	Theodosios Thomas/Jeanine Young
Filer Authorized By:	Theodosios Thomas
Attorney Docket Number:	234/14 UTIL
Receipt Date:	14-JUN-2013
Filing Date:	15-SEP-2006
Time Stamp:	11:54:57
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment		no			
File Listing:					
Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1		C114_373_Statement.pdf	432413	yes	3
			25207f13a10b0cc9ee71f65cbfa977cd2c9a5812		

	Multipart Description/PDF files in .zip description		
	Document Description	Start	End
	Assignee showing of ownership per 37 CFR 3.73.	1	2
	Power of Attorney	3	3
Warnings:			
Information:			
Total Files Size (in bytes):		432413	
This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503. <u>New Applications Under 35 U.S.C. 111</u> If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application. <u>National Stage of an International Application under 35 U.S.C. 371</u> If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course. <u>New International Application Filed with the USPTO as a Receiving Office</u> If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.			

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Patent Application of:

Inventor: Mark Lande

Application Number: 11/532,125

Filed: 9/15/2006

Customer No.: 114420

Confirmation Number: 2294

Group Art Unit: 2611

Examiner: Kevin Kim

For: Combinational Hybrid Turbo-MUD

Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

STATEMENT UNDER 37 CFR 3.73(b)

IN ACCORDANCE WITH 37 CFR 3.71(a), PROSECUTION OF THE PRESENT APPLICATION SHALL BE CONDUCTED BY THE ASSIGNEE, TO THE EXCLUSION OF THE INVENTOR(S).

Applicant, **Collision Communications, Inc.**, a Limited Liability Company, states that it is:

1. ☒ the assignee of the entire right, title, and interest; or
2. ☐ an assignee of less than the entire right, title, and interest
(The extent (by percentage) of its ownership interest is _____ %)

in the patent application identified above by virtue of an assignment from the inventor(s) to the current assignee as follows:

1. From: **Inventor(s)** To: **BAE Systems Information And Electronic Systems Integration Inc.**
The document was recorded in the United States Patent and Trademark Office at Reel / Frame: **018272 / 0171**, or for which a copy thereof is attached.
2. From: **BAE Systems Information And Electronic Systems Integration Inc.** To: **Collision Technology LLC**
The document was recorded in the United States Patent and Trademark Office at Reel / Frame: **026190 / 0812**, or for which a copy thereof is attached.

Additional documents in the chain of title are listed on a supplemental sheet.

As required by 37 CFR 3.73(b)(1)(i), the documentary evidence of the chain of title from the original owner to the assignee was, or concurrently is being, submitted for recordation pursuant to 37 CFR 3.11.

[NOTE: A separate copy (i.e., a true copy of the original assignment document(s)) must be submitted to the Assignment Division in accordance with 37 CFR Part 3, to record the assignment in the records of the USPTO. See MPEP 302.08]

The undersigned (whose title is supplied below) is authorized to act on behalf of the assignee.

Signature: _____

Theodosios Thomas

Reg. No. 45159, Patent Counsel, Phone No. 919-233-1942 x-203

Date: _____

06 / 06 / 13

STATEMENT UNDER 37 CFR 3.73(c)
(Supplemental Sheet)

3. From: **Collision Technology LLC** To: **Collision Communications, Inc.**

The document was recorded in the United States Patent and Trademark Office at Reel / Frame:
028490 / 0285, or for which a copy thereof is attached.



UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
Address: COMMISSIONER FOR PATENTS
P.O. Box 1450
Alexandria, Virginia 22313-1450
www.uspto.gov

APPLICATION NUMBER	FILING OR 371(C) DATE	FIRST NAMED APPLICANT	ATTY. DOCKET NO./TITLE
11/532,125	09/15/2006	Mark Lande	234/14 UTIL

79683
OLIVE LAW GROUP, PLLC
125 EDINBURGH SOUTH DRIVE, SUITE 100
CARY, NC 27511

CONFIRMATION NO. 2294
POWER OF ATTORNEY NOTICE



OC000000062161097

Date Mailed: 06/28/2013

NOTICE REGARDING CHANGE OF POWER OF ATTORNEY

This is in response to the Power of Attorney filed 06/14/2013.

- The Power of Attorney to you in this application has been revoked by the assignee who has intervened as provided by 37 CFR 3.71. Future correspondence will be mailed to the new address of record(37 CFR 1.33).

/ttkim/

Office of Data Management, Application Assistance Unit (571) 272-4000, or (571) 272-4200, or 1-888-786-0101



UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
Address: COMMISSIONER FOR PATENTS
P.O. Box 1450
Alexandria, Virginia 22313-1450
www.uspto.gov

APPLICATION NUMBER	FILING OR 371(C) DATE	FIRST NAMED APPLICANT	ATTY. DOCKET NO./TITLE
11/532,125	09/15/2006	Mark Lande	C114/US

CONFIRMATION NO. 2294

POA ACCEPTANCE LETTER



OC000000062161099

114420
Collision Communications, Inc.
5400 Trinity Road
Suite 303
Raleigh, NC 27607

Date Mailed: 06/28/2013

NOTICE OF ACCEPTANCE OF POWER OF ATTORNEY

This is in response to the Power of Attorney filed 06/14/2013.

The Power of Attorney in this application is accepted. Correspondence in this application will be mailed to the above address as provided by 37 CFR 1.33.

/ttkim/

Office of Data Management, Application Assistance Unit (571) 272-4000, or (571) 272-4200, or 1-888-786-0101

AO 120 (Rev. 08/10)

TO: Mail Stop 8 Director of the U.S. Patent and Trademark Office P.O. Box 1450 Alexandria, VA 22313-1450	REPORT ON THE FILING OR DETERMINATION OF AN ACTION REGARDING A PATENT OR TRADEMARK
---	---

In Compliance with 35 U.S.C. § 290 and/or 15 U.S.C. § 1116 you are hereby advised that a court action has been filed in the U.S. District Court Eastern District of Texas on the following

☐ Trademarks or ☒ Patents. (☐ the patent action involves 35 U.S.C. § 292.);

DOCKET NO. 2:21-cv-308	DATE FILED 8/10/2021	U.S. DISTRICT COURT Eastern District of Texas
PLAINTIFF Collision Communications, Inc.		DEFENDANT Nokia Corporation, Nokia Solutions and Networks Oy, and Nokia of America Corporation
PATENT OR TRADEMARK NO.	DATE OF PATENT OR TRADEMARK	HOLDER OF PATENT OR TRADEMARK
1 7,233,620	6/19/2007	Collision Communications, Inc.
2 7,593,492	9/22/2009	Collision Communications, Inc.
3 7,724,851	5/25/2010	Collision Communications, Inc.
4 9,814,071	11/7/2017	Collision Communications, Inc.
5 9,888,479	2/6/2018	Collision Communications, Inc.

In the above—entitled case, the following patent(s)/ trademark(s) have been included:

DATE INCLUDED	INCLUDED BY ☐ Amendment ☐ Answer ☐ Cross Bill ☐ Other Pleading	
PATENT OR TRADEMARK NO.	DATE OF PATENT OR TRADEMARK	HOLDER OF PATENT OR TRADEMARK
1		
2		
3		
4		
5		

In the above—entitled case, the following decision has been rendered or judgement issued:

DECISION/JUDGEMENT

CLERK	(BY) DEPUTY CLERK	DATE
-------	-------------------	------

Copy 1—Upon initiation of action, mail this copy to Director Copy 3—Upon termination of action, mail this copy to Director
 Copy 2—Upon filing document adding patent(s), mail this copy to Director Copy 4—Case file copy

AO 120 (Rev. 08/10)

TO: Mail Stop 8 Director of the U.S. Patent and Trademark Office P.O. Box 1450 Alexandria, VA 22313-1450	REPORT ON THE FILING OR DETERMINATION OF AN ACTION REGARDING A PATENT OR TRADEMARK
---	---

In Compliance with 35 U.S.C. § 290 and/or 15 U.S.C. § 1116 you are hereby advised that a court action has been filed in the U.S. District Court Eastern District of Texas on the following

☐ Trademarks or ☒ Patents. (☐ the patent action involves 35 U.S.C. § 292.);

DOCKET NO. 2:21-cv-308	DATE FILED 8/10/2021	U.S. DISTRICT COURT Eastern District of Texas
PLAINTIFF Collision Communications, Inc.		DEFENDANT Nokia Corporation, Nokia Solutions and Networks Oy, and Nokia of America Corporation
PATENT OR TRADEMARK NO.	DATE OF PATENT OR TRADEMARK	HOLDER OF PATENT OR TRADEMARK
1 10,477,561	11/12/2019	Collision Communications, Inc.
2		
3		
4		
5		

In the above—entitled case, the following patent(s)/ trademark(s) have been included:

DATE INCLUDED	INCLUDED BY ☐ Amendment ☐ Answer ☐ Cross Bill ☐ Other Pleading	
PATENT OR TRADEMARK NO.	DATE OF PATENT OR TRADEMARK	HOLDER OF PATENT OR TRADEMARK
1		
2		
3		
4		
5		

In the above—entitled case, the following decision has been rendered or judgement issued:

DECISION/JUDGEMENT

CLERK	(BY) DEPUTY CLERK	DATE
-------	-------------------	------

Copy 1—Upon initiation of action, mail this copy to Director Copy 3—Upon termination of action, mail this copy to Director
 Copy 2—Upon filing document adding patent(s), mail this copy to Director Copy 4—Case file copy

AO 120 (Rev. 08/10)

TO: Mail Stop 8 Director of the U.S. Patent and Trademark Office P.O. Box 1450 Alexandria, VA 22313-1450	REPORT ON THE FILING OR DETERMINATION OF AN ACTION REGARDING A PATENT OR TRADEMARK
---	---

In Compliance with 35 U.S.C. § 290 and/or 15 U.S.C. § 1116 you are hereby advised that a court action has been filed in the U.S. District Court Eastern District of Texas on the following

☐ Trademarks or ☒ Patents. (☐ the patent action involves 35 U.S.C. § 292.);

DOCKET NO. 2:21-cv-00327	DATE FILED 8/27/2021	U.S. DISTRICT COURT Eastern District of Texas
PLAINTIFF Collision Communications, Inc.		DEFENDANT Telefonaktiebolaget LM Ericsson and Ericsson Inc.
PATENT OR TRADEMARK NO.	DATE OF PATENT OR TRADEMARK	HOLDER OF PATENT OR TRADEMARK
1 7,233,620	6/19/2007	Collision Communications, Inc.
2 7,593,492	9/22/2009	Collision Communications, Inc.
3 7,724,851	5/25/2010	Collision Communications, Inc.
4 9,814,071	11/7/2017	Collision Communications, Inc.
5		

In the above—entitled case, the following patent(s)/ trademark(s) have been included:

DATE INCLUDED	INCLUDED BY ☐ Amendment ☐ Answer ☐ Cross Bill ☐ Other Pleading	
PATENT OR TRADEMARK NO.	DATE OF PATENT OR TRADEMARK	HOLDER OF PATENT OR TRADEMARK
1		
2		
3		
4		
5		

In the above—entitled case, the following decision has been rendered or judgement issued:

DECISION/JUDGEMENT

CLERK	(BY) DEPUTY CLERK	DATE
-------	-------------------	------

Copy 1—Upon initiation of action, mail this copy to Director Copy 3—Upon termination of action, mail this copy to Director
 Copy 2—Upon filing document adding patent(s), mail this copy to Director Copy 4—Case file copy