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Visitors to VTC2002-Fall in Vancouver had the chance to sample North America's second largest trolleybus system, which is almost as energy efficient as the SkyTrain system. Efficient tramways without wires are discussed by Sébastien Gay & Mark Ehsani.

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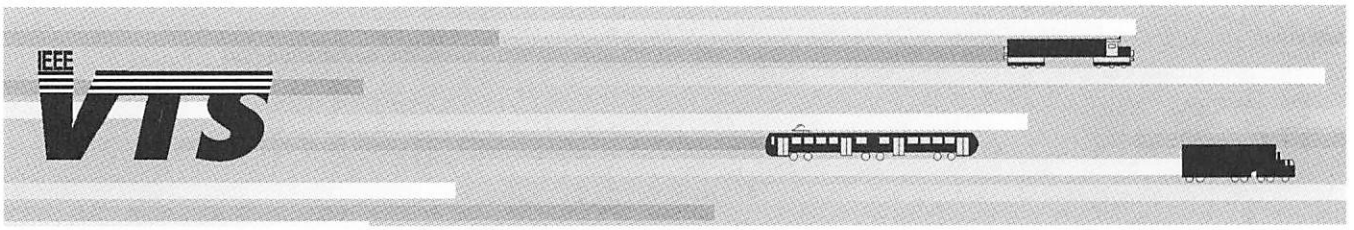

Foreword

James Irvine, Editor

Welcome to the first issue of Volume 50 of the VTS News.

The Vehicular Technology Society is one of the oldest IEEE societies. We can trace our history back to the Institute of Radio Engineers (IRE), whose Committee on Vehicular and Railroad Radio Communication was formed in 1949. The name quickly changed to the Professional Group on Vehicular Communications, and the first annual conference held in Detroit in 1950. The Transactions of the IRE PGVC began publication in 1951. The Group's newsletter was started the same year.

Anniverseries are always a good time to take stock, and we will be taking the opportunity of volume 50 to review past achievements and perhaps refresh a few memories. Board Member Sam McConoughey has summarised the Board minutes going right back to the Group's foundation, and we will be dipping into that document from time to time. Each issue this year will focus on one aspect of the Society's past, and we start in this issue with the John R. Evans Avant Garde Award, which was itself started in 1980 to mark the efforts of the pioneers of the Society or what was then the past 30 years.

It would not be possible for the VTS News to have made it to 50 volumes without the dedication of volunteers who take the time to write for each issue. I would like to extend my thanks to the team of Senior Editors – Bill Fleming (Automotive Electronics), Gaspar Messina (Chapter News), Frank Lord (Professional Activities), Harvey Glickenstein (Land Transportation), Javier Gozalvez (Mobile Radio), Dennis Bodson (Standards) and Dirk Pesch (Book Reviews) without whom there wouldn't be a newsletter to edit. Thanks are also due to the IEEE staff who carry out the typesetting and oversee production, and over my time as editor, Andrea Watson, Robin Edwards, Jackie Parker, Paul Doto and Production Director Bob Smrek have all been responsible for ensuring that copy reaches you in a more readable form than it leaves me.

To get you started, here is a question for you: I listed the editors in chronological order, so when did Bill Fleming start writing his Automotive Electronics column? Answer on the inside back cover.

All the best for 2003!

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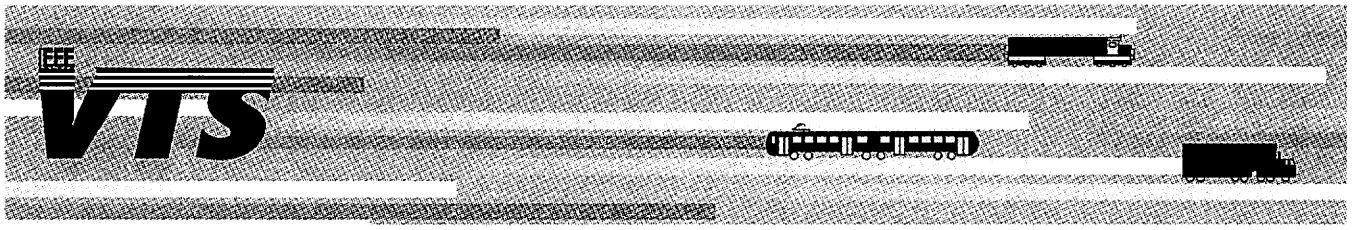

High Speed Downlink Packet Access: WCDMA Evolution

Troels Emil Kolding, Klaus Ingemann Pedersen, Jeroen Wigard, Frank Frederiksen & Preben Elgaard Mogensen, Nokia Networks

This article gives an overview of the high speed downlink packet access (HSDPA) concept; a new feature which is coming to the Release 5 specifications of the 3GPP WCDMA / UTRA-FDD standard. To support an evolution towards more sophisticated network and multimedia services, the main target of HSDPA is to increase user peak data rates, quality of service, and to generally improve spectral efficiency for downlink asymmetrical and bursty packet data services. This is accomplished by introducing a fast and complex channel control mechanism based on a short and fixed packet transmission time interval (TTI), adaptive modulation and coding (AMC), and fast physical layer (L1) hybrid ARQ. To facilitate fast scheduling with a per-TTI resolution in coherence with the instantaneous air interface load, the HSDPA-related MAC functionality is moved to the Node-B. The HSDPA concept facilitates peak data rates exceeding 2 Mbps (theoretically up to and exceeding 10 Mbps), and the cell throughput gain over previous UTRA-FDD releases has been evaluated to be in the order of 50-100% or even more, highly dependent on factors such as the radio environment and the service provision strategy of the network operator.

Introduction

Data services are anticipated to have an enourmous rate of growth over the next years (the so-called data tornado) and will likely become the dominating source of traffic load in 3G mobile cellular networks. Example applications to supplement speech services include multiplayer games, instant messaging, online shopping, face-to-face videoconferences, movies, music, as well as personal/public database access. As more sophisticated services evolve, a major challenge of cellular systems design is to achieve a high system capacity and simultaneously facilitate a mixture of diverse services with very different quality of service (QoS) requirements. Various traffic classes exhibit very different traffic symmetry and bandwidth requirements. For example, two-way speech services (conversational class) require strict adherence to channel symmetry and very tight latency, while Internet download services (background class) are often asymmetrical and are tolerant to latency. The streaming class, on the other hand, typically exhibits tight latency requirements with most of the traffic carried in the downlink direction.

Already in Release 99 of the WCDMA/UTRA specifications, there exist several types of downlink radio bearers to facilitate efficient transportation of the different service classes. The forward access channel (FACH) is a common channel offering low latency. However, as it does not apply fast closed loop power control it exhibits limited spectral efficiency and is in practice limited to carrying only small data amounts. The dedicated channel (DCH) is the "basic" radio-bearer in WCDMA/UTRA and supports all traffic classes due to high parameter flexibility. The data rate is updated by means of variable spreading factor (VSF) while the block error rate (BLER) is controlled by inner and outer loop power control mechanisms. However, the power and hardware efficiency of the DCH is limited for bursty and high data rate services since channel reconfiguration is a rather slow process (in the range of 500 ms). Hence, for certain Internet services with high maximum bit rate allocation the DCH channel utilization can be rather low. To enhance trunking efficiency, the downlink shared channel (DSCH) provides the possibility to time-multiplex different users (as opposed to code multiplexing) [1]. The benefit of the DSCH over the DCH is a fast channel reconfiguration time and packet scheduling procedure (in the order of 10 ms intervals). The efficiency of the DSCH can be significantly higher than for the DCH for bursty high data rate traffic [2].

The HSDPA concept can be seen as a continued evolution of the DSCH and the radio bearer is thus denoted the high speed DSCH (HS-DSCH) [3]. As will be explained in the following sections, the HSDPA concept introduces several adaptation and control mechanisms in order to enhance peak data rates, spectral efficiency, as well as QoS control for bursty and downlink asymmetrical packet data [4]. In this paper, issues of importance to radio resource management (RRM) are discussed and UE capability implications are introduced. Next, the potential performance of the HSDPA concept is evaluated for different environments before the paper is concluded with a short discussion of further HSDPA enhancements proposed for future 3GPP standard releases. At the time of this writing, the Release 5 specifications have not yet been frozen so the specific details may be subject to change.

Concept Description

The fundamental characteristics of the HS-DSCH and the DSCH are compared in Table 1. On the HS-DSCH, two fundamental CDMA features, namely variable spreading factor (VSF) and fast power control, have been deactivated and replaced by AMC, short packet size, multi-code operation, and fast L1 hybrid ARQ (HARQ). While being more complicated, the replacement of fast power control with fast AMC yields a power efficiency gain due to an elimination of the inherent power control overhead. Specifically, the spreading factor (SF) has been fixed to 16, which gives a good data rate resolution with reasonable complexity. In order to increase the link adaptation rate and efficiency of the AMC, the packet duration has been reduced from normally 10 or 20 ms down to a fixed duration of 2 ms. To achieve low delays in the link control, the MAC functionality for the HS-DSCH has been moved from the RNC to the Node-B. This is a noticeable architectural change compared to the Release 99 architecture.

Feature	DSCH	HS-DSCH
Variable spreading factor (VSF)	Yes (4-256)	No (16)
Fast power control	Yes	No
Adaptive modulation and coding (AMC)	No	Yes
Fast L1 HARQ	No	Yes
Multi-code operation	Yes	Yes, extended
Transmission time interval (TTI)	10 or 20 ms	2 ms
Location of MAC	RNC	Node-B

***Table 1** Comparison of fundamental propeties of DSCH and HS-DSCH.*

This leads to significant software and hardware changes compared to the existing Release 99 Node-B implementation. For the HS-DSCH, only hard handover is supported as of the Release 5 specifications.

Modulation and coding options in HSDPA

To substitute the functionality of fast power control and VSF, the modulation, coding, and multi-code part of HSDPA must cover a wide dynamic range corresponding to the channel quality variations experienced at the UE (including fast as well as distance-dependent variations). The means of adaptation are the code rate, the modulation scheme, the number of multi-codes employed, as well as the transmit power per code. The HS-DSCH encoding scheme is based on the Release 99 rate-1/3 Turbo encoder but adds rate matching with puncturing and repetition to obtain a high resolution on the effective code rate (approximately from 1/6 to 1/1). To facilitate very high peak data rates, the HSDPA concept adds 16QAM on top of the existing QPSK scheme available in Release 99. The combination of 16QAM and e.g. rate-¾ channel encoding enables a peak data rate of 712 kbps per code (SF=16). Higher robustness is available with a QPSK rate-¼ scheme but at the penalty of having only a 119 kbps data rate per code. A modulation and coding combination is sometimes denoted a transport format and resource combination (TFRC). Five example TFRCs available on the HS-DSCH are shown in Table 2. Given sufficiently good channel conditions, a single user may simultaneously receive up to 15 parallel multi-codes leading to very high peak data rates up to 10.8 Mbps. This is the maximum peak data rate supported by the HSDPA concept, which can only be achieved in very favourable environments or with advanced transmission and reception technologies. It will be shown in a later section that the HSDPA concept defines a number of UE capability classes, and that only the high-end UE classes will support the very high data rates.

The dynamic range of the AMC for a single code is illustrated in Figure 1 showing the available user data rate versus the instantaneous (per-TTI) E_s/N_0. The curve includes the gain from fast HARQ based on chase combining which significantly improves the throughput at low E_s/N_0 values.

TFRC	Modulation	Eff. Code Rate	Data rate (1 code)	Data rate (5 codes)	Data rate (15 codes)
1	QPSK	¼	119 kbps	0.6 Mbps	1.8 Mbps
2	QPSK	½	237 kbps	1.2 Mbps	3.6 Mbps
3	QPSK	¾	356 kbps	1.8 Mbps	5.3 Mbps
4	16QAM	½	477 kbps	2.4 Mbps	7.2 Mbps
5	16QAM	¾	712 kbps	3.6 Mbps	10.8 Mbps

***Table 2** Example transport format and resource combinations and corresponding user data rates at layer 1 (including overhead). More options for TFRCs are given in [1,3].*

The E_s/N_0 range from where the throughput of TFRC1 is larger than 32 kbps to where the data rate of TFRC5 saturates to the maximum throughput of 712 kbps is on the order of 20 dB. As is also shown in Figure 1, the AMC curve becomes smoother when using multiple codes, i.e. multi-code operation provides increased granularity of the AMC. Further, multi-code operation enhances the dynamic range of AMC by the number of available codes. Hence, the total dynamic range of for instance AMC with 15 multi-codes is on the order of 32 dB. If all the code rate resolution available to HSDPA is utilized this will also lead to a smoother AMC curve than presented in Figure 1, which only includes the five example schemes of Table 2.

L1 retransmission techniques

The HARQ protocol selected for HSDPA is stop and wait (SAW). In SAW, the transmitter persists on the transmission of the current block until it has been successfully received by the UE. In order to avoid waiting times for acknowledgements, N parallel SAW-ARQ processes may be set for the UE, so that different processes transmit in separate TTIs. The value for N may maximally be 8 but in practice, the delay between the original and the first retransmission is expected to be on the order of 8-12 ms. The control of the L1 HARQ is located in the MAC-hs, so that the storage of unacknowledged data packets and the following scheduling

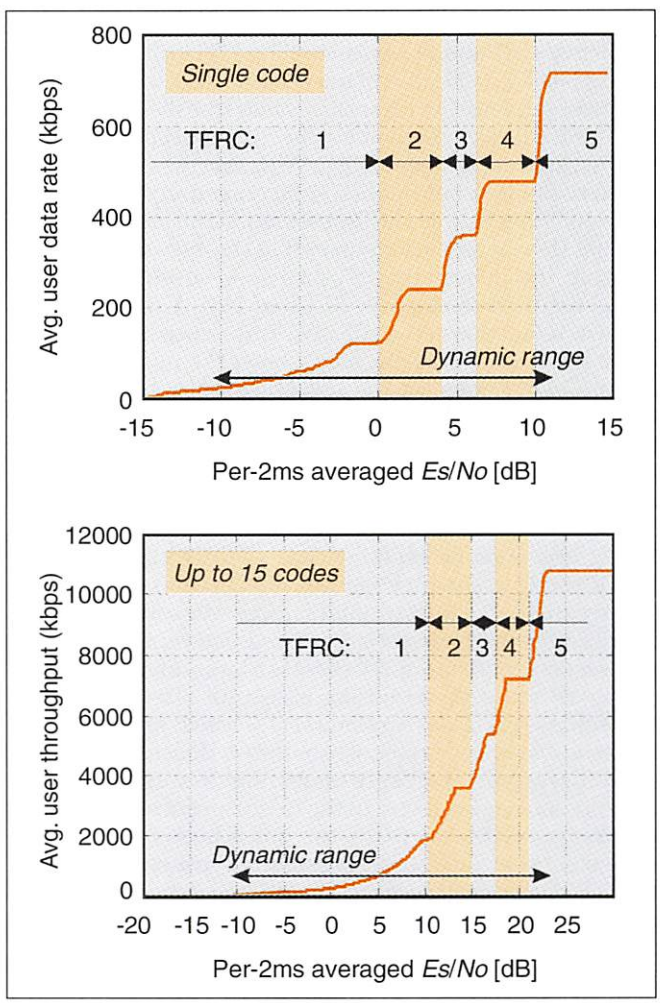

Figure 1 Dynamic range of the HSDPA AMC. Simulation assumptions: RAKE receiver, ITU Pedestrian-A profile, 3km/h.

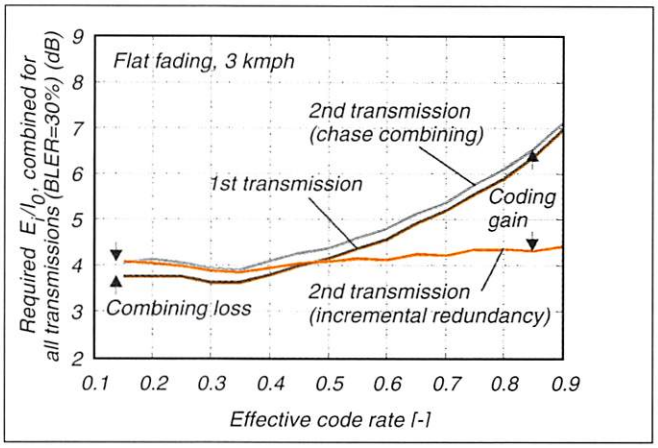

Figure 2 Performance of different retransmission strategies.

of retransmissions does not involve the RNC. Hence, Iub signaling is avoided and the resulting retransmission delay of HSDPA becomes much lower than for conventional RNC retransmissions. The HSDPA retransmission procedure is thus several orders of magnitude faster than the conventional RNC based ARQ implementation and enables the use of advanced retransmission strategies with lower delay jittering and higher spectral efficiency, even for delay sensitive services like streaming.

The HSDPA concept supports both the incremental redundancy (IR) and chase combining (CC) retransmission strategies. The basic idea of the CC scheme is to transmit an identical version of an erroneously detected data packet and then for the decoder to combine the received copies weighted by the SNR prior to decoding. With the IR scheme, additional redundant information is incrementally transmitted if the decoding fails on the first attempt. The performance of CC and IR schemes are compared in the curves of Figure 2 showing the information bit energy to interference ratio (E_i/I_0) required to obtain a BLER of 30%. E_i/I_0 values are given as a function of the effective Turbo encoding rate. The curve labeled "1st transmission" shows the required E_i/I_0 if successful detection is to be accomplished in a single transmission with a probability of 30%. The curves labeled "2nd transmission" indicate the required E_i/I_0 calculated as the linear sum of the E_i/I_0 of the two individual transmissions, still at a 30% probability of correctly detecting the packet. As can be seen for the case of chase combining, a slight combining loss must be expected (loss slightly higher if lower BLER target is set after second transmission). This loss is mainly attributed to the combining operation itself, which is based on the combining of soft information values. As can be noticed for a code rate of 3/4, there is a large advantage of applying IR since the resulting code rate after the second transmission is close to optimum (1/3 which is the base encoder rate). For code rates of ½ or lower, IR does not provide a significant gain over chase combining since almost all code information has been sent in the first transmission. The disadvantage of IR over CC is the much higher memory requirements for the UE. The possibility to utilize IR for a certain TFRC and multi-code combination is defined by the UE capability class. Depending on the data rate compared to the UE capability as well as the code rate of the first transmission, aspects of both the CC and the IR schemes will be utilized in the retransmissions. When 16QAM is used as the modulation scheme, two of the four bits constructing the received symbols will have a higher probability of error than the other two bits. In order to compensate for this effect it is possible to use constellation re-arrangement for retransmissions, which provides a swapping of the bit streams in a way that all bits experience the same average level of error probability after the retransmission combining.

Retransmission utilization for a user depends on whether the channel quality is generally in the lower or the upper end of the AMC dynamic range and if it exceeds this dynamic range. For optimal spectral efficiency and a simple round-robin scheduling scheme (without consideration of hardware and code utilization issues), users located at the cell edge will experience an average first transmission BLER around 30-60%, while users located in the vicinity of the Node-B will operate with a first transmission BLER around 10-20%. The reason for the higher BLER at the cell edge is that a user in bad conditions will more often be in a condition where even the most robust TFRC cannot be received without error in the 1st transmission.

Spectral and code efficiency

Before reaching the pole capacity, a synchronous WCDMA system may be capacity limited due to either a power shortage or a code shortage. One of the major benefits of the HSDPA concept is the ability to make a tradeoff among power and code efficiency to accommodate the current state of the cell. This aspect is illustrated in Figure 3, where the five example TFRCs are plotted in a diagram showing both their power efficiency (measured as allowed noise power to user bit energy ratio for a BLER of 10%, e.g. I_0/E_i) and their respective code efficiency (measured as supported data rate per code). If the Node-B has relatively more power resources than code resources available (code limited), the link adaptation algorithm will optimize for a more code efficient TFRC while a more robust TFRC with more multi-codes will be used when the Node-B is mainly power limited.

Link adaptation and support channels

The overall concept of the HS-DSCH link adaptation (LA) is illustrated in Figure 4. The Node-B tracks the radio channel quality in the downlink direction by monitoring the transmit power on the downlink associated DCH (adjusted via control commands available on the uplink associated DCH). The UE can also be requested to regularly send a specific channel quality indicator (CQI) on the uplink high speed

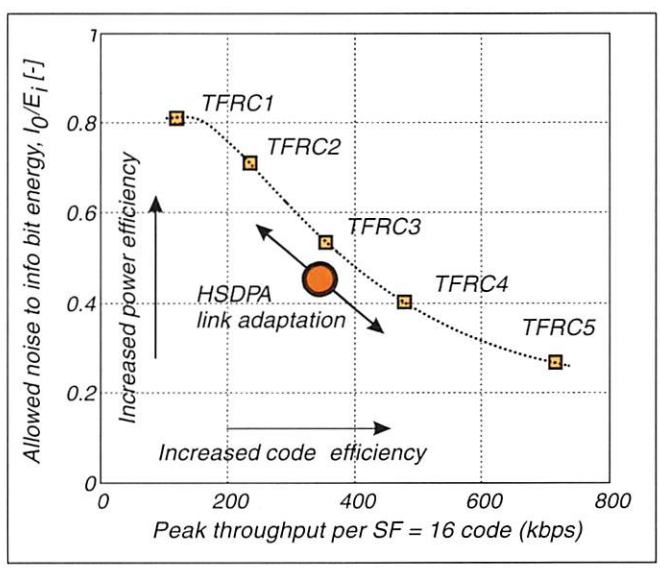

Figure 3 Power and code effciency for different TFRCs.

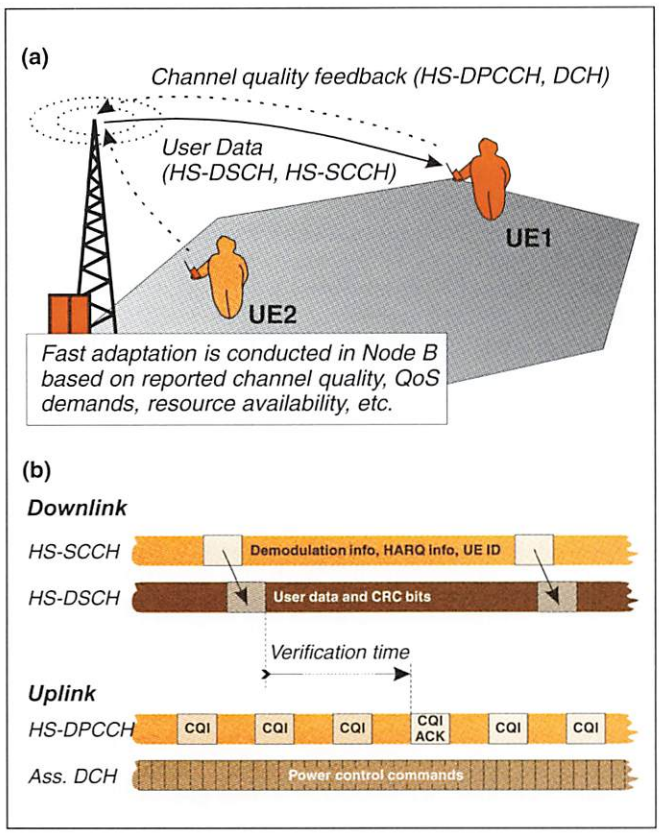

Figure 4 The general HSDPA operating principle is shown in (a) and inter-channel operation is illustrated in (b).

dedicated physical control channel (HS-DPCCH). The CQI is an indicator of the TFRC and multi-code number currently supported by the UE (e.g. the supported data rate). The feedback cycle of the HS-DPCCH CQI can be set as a network parameter in predefined steps from 2 ms to infinite time (i.e. disabled). The power of the HS-DPCCH is set as an offset compared to the uplink dedicated physical control channel (DPCCH) and to guarantee full cell-coverage a CQI repetition scheme can be used. For the Node-B to know if a transmitted packet was detected correctly or wrongly in the receiver end, the UE is required to send a CRC-based ACK/NACK response on the HS-DPCCH. It is up to the Node-B (and thus the manufacturer/operator) to decide whether it will base its link adaptation strategy primarily on the associated DCH power control commands, the HS-DPCCH information, or a combination of the two.

Depending on packet prioritization and resource availability, the Node-B then schedules data to the users on the HS-DSCH. In this sense, two users may be both time and/or code multiplexed to better utilize the available resources under the constraint of having different UE capability classes. Prior to sending data on the HS-DSCH, the Node-B sends a detailed demodulation message to the active users via the high speed shared control channel (HS-SCCH). This information describes the employed TFRC, the multi-code set, as well as the H-ARQ process control and is transmitted 2 slots in advance of the HS-DSCH. The UE being active on the HS-DSCH must be capable of receiving up to four parallel HS-SCCHs in order to determine if data is being transmitted to the UE in the following time period. Masking the CRC field on the HS-SCCH with a unique UE ID facilitates the UE identification process. The power of the HS-SCCH is controlled by the Node-B and it may have a time-variant power. The HS-DSCH contains user data as well as a single 24-bit CRC field that is calculated over all the transmitted multi-codes (i.e. one logical transport channel maps into several physical channels). This approach yields a Turbo coding gain for larger data rates where the encoding block size increases.

UE Capabilities

With the introduction of the HSDPA concept into the Release 5 specifications, a new generation of UE capability classes will be introduced. Five main parameters are used to define the physical layer UE capability level [5]:

- Maximum number of HS-DSCH multi-codes that the UE can simultaneously receive. At least five multi-codes must be supported in order to facilitate efficient multi-code operation.
- Minimum inter-TTI interval, which defines the distance from the beginning of a TTI to the beginning of the next TTI that can be assigned to the same UE. E.g. if the allowed interval is 2 ms, this means that the UE can receive HS-DSCH packets every 2 ms.
- Maximum number of HS-DSCH transport channel bits that can be received within a single TTI.
- The maximum number of soft channel bits over all the HARQ processes.
- If the UE supports 16QAM (e.g. code efficiency limitation).

Further, parameters are specified for informing the network what is the total L2 buffer capability (MAC and RLC) in the UE. Examples of UE capability classes proposed in 3GPP are listed in Table 3, but more combinations are possible [5]. Note that a 'low-end' HSDPA UE will support a maximum of 5 simultaneous HS-DSCH codes, and the minimum distance between the starting points of two successive data packets is 3 TTIs (i.e. 6 ms). Such a UE will support a maximum of 7300 bits in each TTI and thus belong to the 1.2 Mbps class. Another important difference is the amount of soft channel bits defined for each UE class. The number of soft channel bits will impact the UE receiver performance when HARQ is employed. A UE with a low number of soft channel bits will not be able to support IR for the highest peak data rates and its performance will thus be slightly lower than for a UE supporting a larger number of soft channel bits.

Architecture Issues and RRM

It is entirely up to the network operator to choose a policy for weighting the different offered services, the subscription

Reference combination	1.2 Mbps class	3.6 Mbps class	7 Mbps class	10 Mbps class
RLC and MAC-hs parameters				
Total RLC AM and MAC-hs buffer size (kbytes)	50	50	100	150
Maximum number of AM RLC entities	6	6	8	8
PHY parameters				
FDD HS-DSCH category	1	5	7	9
Maximum number of bits of HS-DSCH codes received	5	5	10	15
Minimum inter-TTI interval	3 (6 ms)	1 (2 ms)	1 (2 ms)	1 (2 ms)
Maximum number of bits of an HS-DSCH transport block received within an HS-DSCH TTI	7300	7300	14600	20432
Total number of soft channel bits	19200	57600	115200	172800

***Table 3** Example of HS-DSCH UE capability classes [5]. All example catagories support 16QAM.*

classes, etc. This weighting applies to both the priority in the network among other services/users but also to the service quality targets; e.g. in terms of guaranteed data rates, minimum delays, etc. One example is to use a paradigm of having different QoS classes; e.g. the premium, gold, and silver subscription division [6]. The RRM algorithms are responsible for best utilization of the available system resources to meet the service policies adopted by the network provider as well as maximizing the system capacity. Specifically, the RRM algorithms are responsible for implementing a hardware and power resource sharing between the different channel types, so that a Node-B can convey traffic over e.g. the DCHs, DSCH, and HS-DSCH at the same time. The admission control (AC) functionality is critical to obtaining the best tradeoff among capacity and single-service quality. Guaranteeing a negotiated QoS level calls for an efficient and QoS-aware AC mechanism, which adjusts its user admission criterion according to the service requirements of the currently active users as well as the pending new user.

The cell specific power and code resource allocation among different channel types is negotiated in the RNC on a rather slow basis compared to the TTI for the HS-DSCH (using cell reconfiguration messages). The power and code resources reserved for HS-DSCH and HS-SCCH are subsequently reported to the Node-B (MAC-hs) over the open Iub interface [7]. If no power constraints are specified, the Node-B can use all excess power not needed for other traffic for the HS-DSCH. The number of channelization codes for HS-DSCH (SF=16) and HS-SCCH (SF=128) are explicitly dictated by the RNC, while the MAC-hs has the freedom to freely distribute the power between the user data and the control channels. The packet scheduling (PS) is responsible for conducting the scheduling of the users, which have been directed to the HS-DSCH. The complicated scheduling operation must consider UE capability issues (e.g. use of code multiplexing), QoS requirements and priority, pending re-transmissions, user's current channel quality, etc. Subsequently, the link adaptation process and the SAW channel selection process are conducted. As the HS-DSCH offers per-TTI bit rate modification and time/code multiplexing between different users, the MAC-hs, containing the HSDPA PS, link adaptation, and HARQ entities, has been moved to the Node-B. This is illustrated in Figure 5.

Packet scheduling

The high scheduling rate combined with the large AMC dynamic range available with the HSDPA concept, makes it possible to conduct the packet scheduling according to the radio conditions as well as the data amounts to be transmitted to the different users. Hence, the HSDPA concept opens for Waterfilling based packet scheduling strategies for optimized cell throughput/fairness strategies, see e.g. [8,9]. The PS methodologies can generally be characterized by:

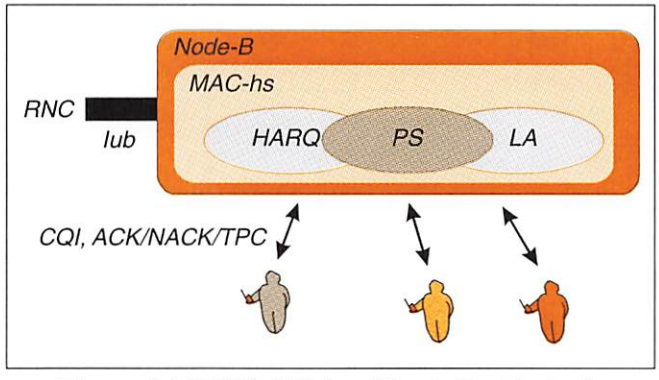

Figure 5 HSDPA RRM entities in the Node-B.

Scheduling period/frequency: The period over which users are scheduled ahead in time. If short, the PS may utilize fast channel variations and track fast fading for low-mobility users. Shorter periods call for higher computational complexity in the Node-B.

Serve order: The order in which users are served; e.g. random order (round robin) or according to channel quality (C/I or throughput based). More advanced order mechanisms require higher computational processing at the Node-B.

Allocation method: The criterion for allocating resources; e.g. same data amount or same power/code/time resources for all queued users per allocation interval.

Some general packet scheduling methods and their characteristics have been compared in Table 4. The fair throughput (FT) scheduler serves users in a random order and according to the same data amount. In theory, all users currently active in the system will therefore experience the same delay and throughput. With the fair resource (FR) scheduler, users receive equal resources in random order and will thus experience different data rates according to their average channel quality. With the C/I PS method (also denoted the thoughput or TP method), the user with the best channel quality is served until the queue is emptied. This leads to a very different service experience among users and to the potential situation where a certain poor-quality user will experience excessive service delays. The scheduling rate for these packet schedulers is assumed to be slow such that fast channel variations are not incorporated (averaging still may be faster than shadowing variations, though). An available option with the HSDPA concept is to make very fast scheduling, which tracks the fast fading variations. Ultimately, users are only scheduled when they are experiencing constructive fading; thereby improving both the user throughput and cell throughput for time-shared channels. The Max C/I or throughput (M-TP) method is the most drastic method, which only serves the best user during the current TTI; e.g. the user who can sustain the highest throughput. Compared to the TP scheduler, this scheduler is fairer to the users since a single user's fading variations typically exceed or are on the order of the average C/I difference between different user locations in the cell. However, the outage of this method is still significant. To obtain a fairer scheduling method, it is possible to define and calculate a relative instantaneous channel quality (RICQ) measure as a selection and prioritization metric. The RICQ measure is often identical to the ratio of the user's instantaneous throughput and the user's average served throughput [9]. In calculation, it utilizes the CQI information as well as the link quality estimation algorithms, which are located in the Node-B. This fast scheduling method is referred to as the proportional fair resource (P-FR) scheduling method as illustrated in Table 4. The proportional scheduling method results in all users getting approximately an equal probability of becoming active even though they may experience very different average channel quality.

The above-mentioned schedulers are "prototype" packet schedulers, which use different means to utilize and distribute excess capacity of the network. They basically yield a very different tradeoff between user fairness and cell capacity. Prioritization based on either QoS constraints or different subscription classes (e.g. premium, gold, and silver users) will in general override the scheduling principles depicted in Table 4 and the scheduling will then only be applied to groups of users/services encompassing the highest

PS method	Scheduling rate	Serve order	Allocation method
Fair throughput (FT)	Slow	Round robin in random order	Resources according to same data amount (up to max. allocation time)
Fair time (FR)	Slow	Round robin in random order	Same resources (time, code, or power) and uneven data amount
C/I or throughput (TP)	Slow	Based on highest average C/I (fast enough to track shadowing)	Same resources (time, code, or power) and uneven data amount
Proportional fair resource (P-FR)	Fast	Based on highest relative instantaneous channel quality (tracks fast fading)	Same resources (time, code, or power) and uneven data amount
Max C/I or throughput (M-TP)	Fast	Based on highest instantaneous channel quality (tracks fast fading)	Same resources (time, code, or power) and uneven data amount

Table 4 *Comparison of different simplified packet scheduling methods [9, 11].*

priority level. When QoS requirements dominate the scheduling strategy, the differentiation between different PS strategies becomes less significant and the capacity gain of the most aggressive schedulers reduces (while becoming more fair).

Performance

The performance of the HS-DSCH depends on a large number of aspects, such as (i) channel conditions including othercell interference and time dispersion, (ii) UE demodulation performance and capability, (iii) nature and accuracy of RRM algorithms, and (iv) hardware imperfections. The throughput performance for a single link employing link adaptation is shown for different channel profiles and average I_{or}/I_{oc} values in Figure 6 versus the code power allocation. In the estimation of the UE channel quality (E_s/N_0) at the Node-B some error must be expected. In these simulations, a lognormally distributed error with a standard deviation of 1 dB and a 2 ms AMC delay have been assumed. In general, the HARQ mechanism makes the LA very robust towards channel estimation errors and scheduling delays. With fast L1 HARQ, the degradation in throughput due to channel estimation errors is approximately halved compared to an AMC system without HARQ [11].

Two different network scenarios are considered for analysis at cell level. The first case (Macrocell/Veh-A) is a macrocell outdoor environment where an ITU Vehicular-A channel profile is assumed (e.g. significant time dispersion). The second case (Microcell/Ped-A) is a microcell outdoor-indoor environment characterized by a favorable I_{or}/I_{oc} distribution due to better cell isolation as well as an ITU Pedestrian-A profile (e.g. limited time dispersion). The I_{or}/I_{oc} distributions are averaged over fast fading and are from [10]. Other simulation assumptions are listed in Table 5.

The fair resource and proportional fair resource schedulers are often considered in conjunction with HSDPA and these have

Parameter	Setting
HSDPA power	75% of Node-B power
Common channel power	20% of Node-B power
HSDPA code allocation	15 (SF=16)
HSDPA cell coverage	90%
Number of users	32
UE velocity	3 kmph
TFRC resolution	See Table 2
Download request	400 kbit for all users
Node-B PCDE*	-36 dB (SF=256)

Table 5 *Simulation Assumptions*

** Simple AWGN model for Node-B hardware imperfections adjusted to Release 5 level of peak code domain error (PCDE).*

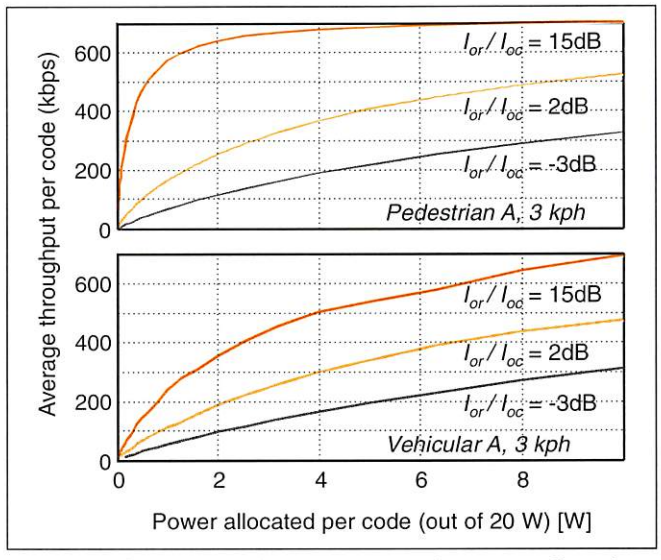

Figure 6 Code throughput versus code power allocation.

been evaluated under the assumptions listed in Table 4. Only one user prioritization class is considered and the packet scheduler operation is not limited by QoS constraints. As TCP and other higher layer protocols are not considered in the evaluation, we attempt a "best effort" type simulation assuming no degradation from e.g. slow start effects. The average cell capacity for the different packet scheduling methodologies are compared in Figure 7 also including reference numbers for Release

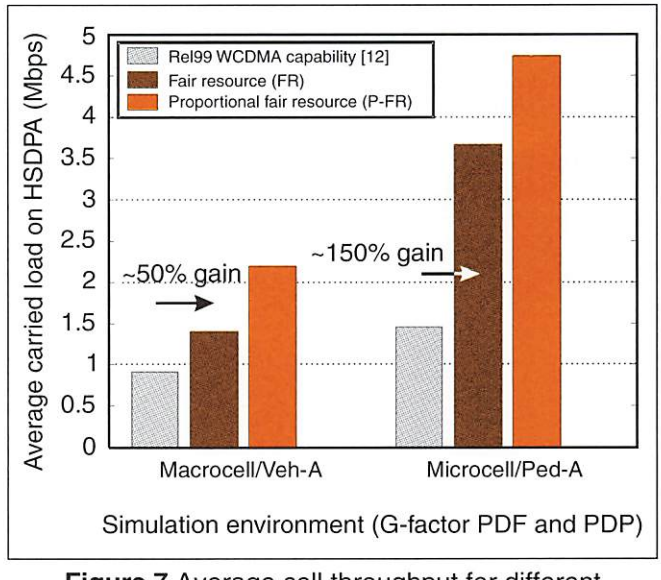

Figure 7 Average cell throughput for different scheduling types.

99 WCDMA obtained from [11]. It is noted that the performance improvement of fast scheduling over slow scheduling is significant for this simulation case with near-optimum conditions. For the macrocell environment the gain in cell throughput is on the order of 56%. For the microcell environment, users are already experiencing very good channel conditions and during good fading conditions they exceed the dynamic range of the AMC. For this reason, the fast scheduling gain reduces to approximately 29%. The available cell throughput for the microcell case exceeds 3.5 Mbps and 4.5 Mbps for the FR and P-FR schedulers respectively. For the interference limited macrocell scenario, the FR throughput is approximately 1.4Mbps. Compared to the numbers for Release 99 performance (denoted by "Rel99 WCDMA"), the cell throughput gain of HS-DSCH exceeds 50% in macrocell and thus significantly more with advanced packet scheduling or in favorable scenarios where the DCH/DSCH becomes code limited [11].

Continued Evolution

HSDPA provides a significant cell capacity gain for packet data traffic in WCDMA and is thus an important part of the continuous 3G evolution. Since the HSDPA concept offers improved code efficiency and dynamic range in user data rates, it can utilize improvements in detector performance foreseen in the future. Hence, it may be viewed as an enabler for more advanced communication techniques, including equalizers, multi-user or multi-code interference cancellation, as well as advanced multiple input multiple output (MIMO) techniques. The HSDPA concept can be introduced gradually in the network with incremental introduction of advanced packet scheduling and link enhancement strategies. The performance and cost/complexity issues of further improvements will be considered within future 3GPP standardization framework to further evolve the WCDMA concept.

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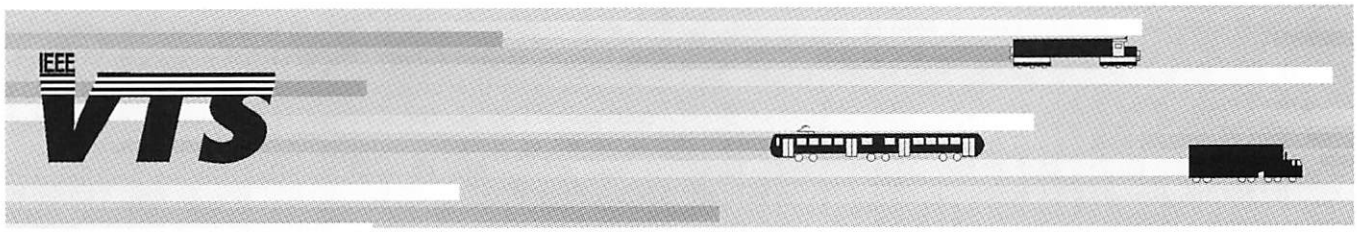

Design of a Fuel Cell Hybrid Tramway

Sébastien E. Gay & Mehrdad Ehsani, Texas A&M University

This paper presents the concept of fuel cell hybrid tramway as a viable alternative to catenary-powered tramways. The feasibility of a fuel cell hybrid tramway based on the analysis of the unique characteristics of the drive cycle of a tramway is discussed. The potential advantages and challenges faced are exposed and future research work on the concept is outlined.

1. Introduction

Tramways are urban rail vehicles that operate on a rather peaky drive-cycle. It is composed of many accelerations and decelerations and the speeds reached are never very high because of the urban environment (pedestrians, cars) and the short distance between two stations. Henceforth, tramways are ideal candidates for hybridization as a means to improve the utilization of the overhead line and energy efficiency. Indeed, the low average speed means that little energy needs to be spent on overcoming the aerodynamic drag and rolling resistance frictions. In addition, the many acceleration and deceleration phases require an efficient peaking system where the kinetic energy is being exchanged between the onboard power source (battery for instance) and the vehicle mass, thus never leaving the vehicle.

It may be desirable for a city to get rid of the overhead line, because it is costly to install and maintain and because it may disfigure a historical downtown. The first argument would be very sensitive in North America where the public transportation use is rather limited and might not justify the cost of installing and maintaining overhead lines and substations. Indeed, this argument has always played against the use of the electric traction.

A solution would then be to replace the overhead line by a fuel cell. As stated in the first paragraph, the most significant advantage deriving from the hybridization is the reduction of the primary energy source, overhead line or fuel cell. Because of its unique drive cycle characteristics, the tramway will only require a small fuel cell and a small source of hydrogen. It is therefore expected to be practical and economically viable. This paper analyses the fundamental characteristics of the tramway drive cycle and proposes a fuel cell hybrid tramway design that optimizes the energy efficiency and minimizes the costs and complexity. The issues discusses will include fuel cell technology, hydrogen source, peaking power source with and emphasis on drive train architectures.

2. Grenoble's Tramway

The transportation authority of the city of Grenoble (France) is operating a modern fleet of 54 low-floor tramways on two downtown lines [1]. These tramways (Figure 1) were built by GEC-Alstom in two batches, the first 39 trains in 1987 and the remaining 15 trains in 1995. The first generation of tramway uses DC motors for traction, while the second generation uses induction motors.

The first generation tramway is propelled by two 375kW motors located in the extreme trucks, while the middle truck only integrate friction brakes. The electric power is picked-up from a at 750V DC overhead line. The maximum speed is 75 km/h with DC motors and 70 km/h with induction motors. Practically however, the speed rarely exceeds 50 km/h due to restrictions in urban environment. Each tramway weights over 44,600kg empty. 54 passengers can be seated and 120 supplementary passengers can travel standing up. The external dimensions of the tramway are 29.4m in length, 2.3m in width, and 3.36m in height.

Photo: Pierre Cussign

Figure 1 Grenoble's Tramway

3. Tramway Drive Cycle

The distance travelled by a tramway was measured by an electronic data logger along with the hour of the day when a given event occurred in the exploitation (start, stop, door opening, door closing, etc...). A sample of the file provided by the data logger is shown below. The first column is the number of the sample; the second column is the distance travelled in meters. The third column is the time of the day and the last column lists the event that occurred.

25: 0 11:42:53 Doors opened
26: 0 11:42:53 A03+
28: 0 11:43:03 A03-
29: 0 11:43:03 Doors closed
30: 0 11:43:11 Go
31: 104 11:43:30
32: 209 11:43:46
34: 313 11:44:00
35: 418 11:44:09
36: 522 11:44:19

The files were processed by a Matlab® program in order to extract information of distance travelled versus time in sec-

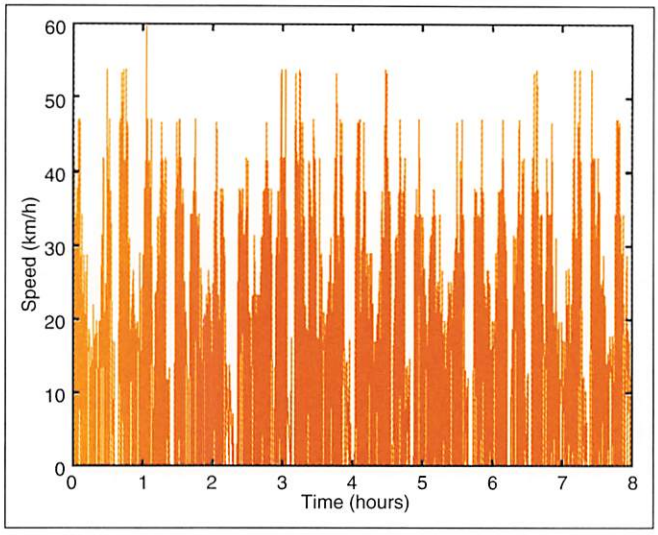

Figure 2 8-hour drive cycle

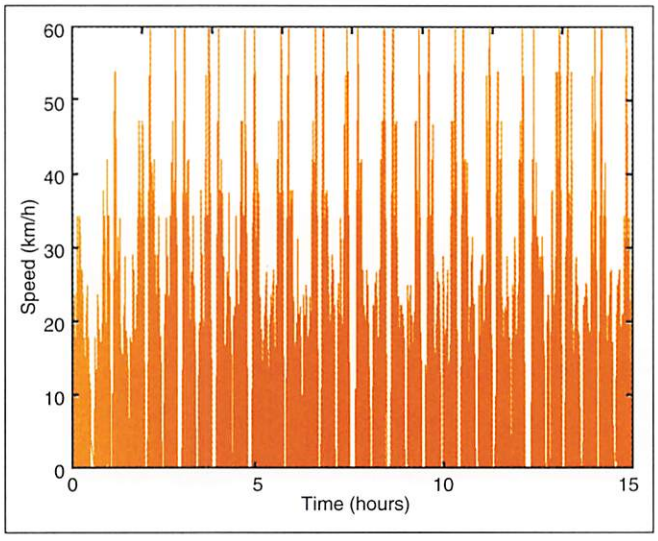

Figure 3 15-hour drive cycle

onds. From these two variables, the average speed between two events, the average drive cycle speed and the acceleration rate can be computed. Figure 2 and Figure 3 show two speed recordings over 8 and 15 hours of operation respectively.

The characteristics of each drive cycle are calculated with the tramway dimensions given in Table 1. The mass is estimated from the maximum empty mass (44,600kg) to which is added a maximum of 174 passengers weighing an estimated average of 60kg. The drive cycle fundamental characteristics are summarized in Table 2. The energy corresponds to the energy necessary to overcome the aerodynamic drag and rolling resistance. The "energy of power" is the integral of the power necessary to accelerate and decelerate the vehicle.

Maximum mass	55,040 kg
Rolling resistance coefficient	0.002
Aerodynamic drag coefficient	0.2
Frontal area	$7.73m^2$
Air density	$1.205\ kg.m^{-3}$

***Table 1** Tramway parameters*

Duration	**8 hours**	**15 hours**
Average speed	15.47 km/h	13.66 km/h
Energy	131.8 MJ	215.5 MJ
"Energy of Power"	681.5 MJ	1174 MJ

***Table 2** Drive cycle fundamental characteristics*

The average speed is very low, due to the frequent stops at stations and red lights. It results that very little energy is required to overcome the aerodynamic drag and the rolling resistance. The traction power is mostly necessary to accelerate and decelerate the vehicle. This is clearly indicated by the "energy of power". This figure is more than 5 times higher than the energy. In a hybrid vehicle, the "energy of power" is the energy that goes back and forth between the peaking power source (battery, ultracapacitor, flywheel) and the mass of the vehicle (kinetic energy). The losses in the peaking power source resulting from this back and forth can be directly calculated from the "energy of power". Because of the low energy and high peaking power required, the tramway is a good candidate for hybridization.

4. A Viable Alternative

A fuel cell hybrid tramway can be a viable alternative to overhead line powered tramways for the following reasons:

- The overhead line and the pantograph are eliminated. The cost of the infrastructure is thus limited to the rails and the signalization. The potential hazards associated with the overhead line are eliminated. Finally, the energy no longer has to go back and forth in the overhead line where it encounters ohmic losses.
- There is no longer a need for sub-stations to supply the overhead line. Because several elements are eliminated, so are the associated losses. If the hydrogen is produced efficiently, then the highly efficient fuel cell will provide significant energy savings.
- Only a small amount of hydrogen is required because the drive cycle energy is low. Indeed, if a 50% efficiency fuel cell is assumed, then only 3.6kg of hydrogen are required for a 15-hour drive cycle (this figure must however be augmented of the losses in the peaking power source). This small amount of hydrogen can be stored very easily. 3.6kg of liquid hydrogen would only occupy a volume of 52 liters [2]. Other hydrogen storage solutions become interesting (metal hydrides, compressed hydrogen, etc...) because of the small amounts required and professional maintenance of the vehicle. In addition, the tramway is much larger than an automobile and offers more flexibility in the packaging of the tank. It can be mounted on the roof with the rest of the traction equipment, thus keeping hydrogen away from the passengers and possible sources of ignition.
- The fuel cell power rating is small because it must only supply the power necessary to overcome the aerodynamic drag and rolling resistance. At maximum speed (60 km/h), the power required is only 22.3kW. If the efficiency of the peaking power source is 80%, then the "energy of power", distributed over the driving time results in a fuel cell power rating of about 27kW. The ancillaries may bring that figure around 30kW, not including the heating and air conditioning. A 30kW stack is well within the capabilities of today's fuel cell technology and does not represent a major challenge since even bigger stacks are envisioned for automobile applications [3,4]. The cost of the fuel cell stack should not be an obstacle because of its small rating and because the purchase cost can be balanced by energy savings in commercial exploitation. In addition, the cost of a fuel cell is likely to be bal-

anced by the absence of substations: the cost shifts from the infrastructure to the vehicle.

- The peaking power source ratings required are within the possibilities of the available technology. A maximum of 750kW is required to supply the traction motors and an energy storage of 7.65 MJ is required to supply the kinetic energy. These can be supplied easily by lithium batteries or ultracapacitors.

A major issue arises from the extremely peaky nature of the drive cycle: the peaking power source must be very energy efficient. Indeed, the many accelerations and decelerations require a lot of power to go back and forth between the peaking power source and the traction motors, encountering losses every time. These losses deplete the peaking power source, which must be recharged by the fuel cell at the expense of some hydrogen fuel.

5. Conclusion

The fuel cell hybrid tramway presents many potential advantages to replace existing overhead line powered tramways or to equip new transportation authorities. The replacements of the complex and costly overhead line infrastructure by an efficient energy source on-board of the vehicle should result in significant purchase cost savings. Furthermore, the drive cycle of the tramway favours hybrid drive trains and fuel cells, two technologies, which combined are capable of reducing significantly the energy consumption. The disadvantages associated with fuel cells, hydrogen and hybrid drive trains are compensated by the inherent characteristics of the vehicle: large space available on the roof, no weight constraint, professional driver and maintenance. Future work on the fuel cell hybrid tramway will investigate the following aspects: hydrogen source, fuel cell technology, energy efficient and compact peaking power source, hybrid energy storage, hybrid drive train architecture and power electronics, control strategy and comparison of energy consumption between overhead line powered and fuel cell hybrid tramway.

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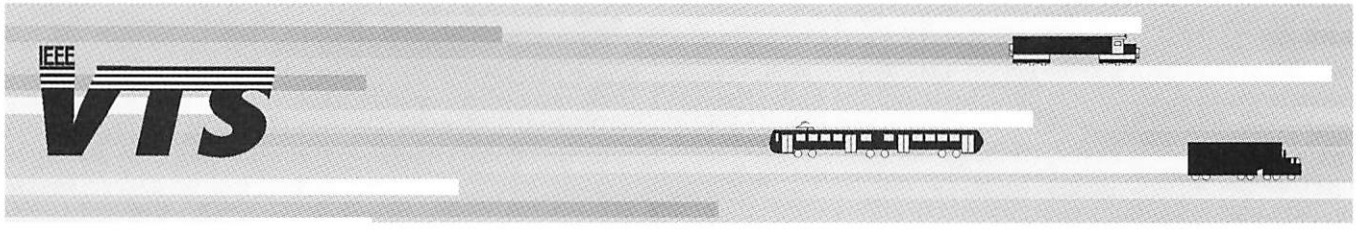

Overview of WCDMA

Jaana Laiho and Antti Toskala, Nokia Networks

3rd Generation Partnership Project (3GPP) produced the first full version of the WCDMA standard in the end of 1999. This release, called release'99, contains all the necessary elements to meet the requirements for IMT-2000 technologies, including 2 Mbps data rate with variable bit rate capability, support of multi-service, flexible physical layer for easy introduction of new services, Quality of service (QoS) differentiation and efficient packet data. This article presents an overview of the WCDMA system, including some fundamentals of the Radio Resource Management (RRM), QoS mechanisms and core network aspects.

1. Introduction

The second generation mobile communication systems, such as GSM or IS-95, were very voice-centric and the deployment of the data services took some time to appear in the market after the systems were introduced. Also many of the data related features were added later on making multiservice cases or introduction of new service difficult from the system perspective. With the Wideband Code Division Multiple Access (WCDMA) technology from 3GPP the simultaneous and transparent support of multiple services, whether packet or circuit switched, was taken into account from the start. The WCDMA radio protocols can provide the radio bearer with wide range of parameters, taking into account the different quality of service needs. This way the development of radio access is independent of the end-user service. This enables an effective way for the service development by the operators and service providers.

The WCDMA network is based on the standardized interfaces, not only over the air but also inside the radio access network. This enables the multivendor network integration

in order to allow e.g. CDMA technology critical features, like soft handover, to be operated seamlessly across the networks. Following the GSM tradition also the interfaces between core and radio access network are standardized to allow the core network and radio access networks from different vendors to work smoothly together. Further this approach ensures both sides, radio access and core, to evolve without need for end to end upgrade of the network in case of a new feature is added.

The WCDMA system deployment has reached the level where first operators in Europe are launching the networks for commercial operation and more operators are to follow during 2003. Currently the main focus shifts from controlling the radio resources to quality management and service and quality differentiation. Following the first WCDMA version, Release'99 now being deployed, the first steps in WCDMA evolution have been completed in the standardisation for improved system performance. The most significant feature completed in Release 5 version of the specifications is the High Speed Downlink Packet Access (HSDPA) as covered in more detail in [1] and also in this issue in the paper by Mogensen et al. Further enhancements are being addressed in the standardisation for further capacity improvements or for reduced cost per bit.

2. WCDMA radio access network architecture

The use of WCDMA radio access technology has shaped the radio access network architecture. Smooth system operation and deployment requires that there are no such network locations where soft handover is not possible between the cells operating on the same frequency as done with CDMA technology. Without the link existing to all base stations impacted, the power control can not operate correctly and near-far problem would be introduced in the uplink.

Figure 1 shows the basic WCDMA radio access network architecture indicating the connections for both circuit switched (Iu-CS) and packet switched (Iu-PS) traffic for the core network. The interface between the base station (denoted as Node B in 3GPP terminology) and the Radio Network Controller (RNC) is called Iub. The interface between two RNCs is denoted as Iur. The open and standardised Iur interface is already being deployed and tested in the multivendor network by many operators and vendors, thus ensuring the soft handover functionality in multivendor environment as well.

The Mobile Switching Center (3G MSC) has basically the same functionality as with GSM networks to switch the Circuit Switched (CS) transactions while the Serving GPRS Support Node (SGSN) performs the similar functions to Packet Switched (PS) services.

More about 3G network architecture can be found for example in [10].

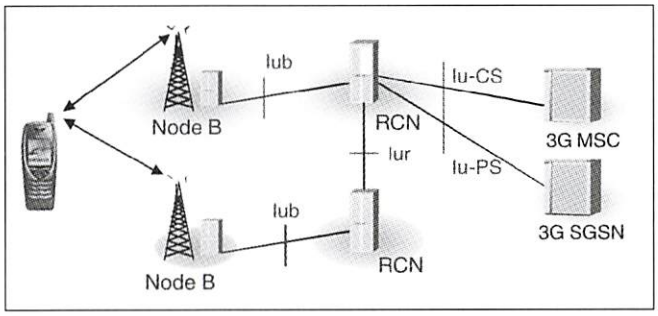

Figure 1 WCDMA Radio Network Architecture

3. WCDMA Logical, transport and physical channels

The channel structure of WCDMA consists of logical, transport and physical channels. This structure is related to the UMTS protocol architecture, see [2]. UTRA FDD protocol architecture is depicted in Figure 2. The physical layer offers services to the medium access control (MAC) layer via transport channels. Transport channels are characterized by *how and with what characteristics* data is transferred. The key functionality of the MAC layer is to select suitable transport format to be used as a function of the data rate. Further in case of transparent RLC mode, the ciphering is done in MAC layer. The MAC layer correspondingly offers services to Radio link control (RLC) layer by means of logical channels. The logical channels are characterised by *what type of data* is transmitted. The RLC layer offers segmentation and retransmission services for the data to be transmitted and handles ciphering unless transparent mode of RLC is in use. The RLC layer contains transmission and reception buffers that handle also in-sequence delivery of the data to higher layers. Further details on the WCDMA layer 2 and 3 protocols can be found in [1] and references therein.

A general classification of logical channels is presented in [2] where the logical channels are divided into two groups - Control Channels and Traffic Channels. The control channels are used for transfer of control plane information and the traffic channels are used for the transfer of user plane information only.

The Control and Traffic Channels can be summarized as follows:

- Broadcast Control Channel (BCCH), for broadcasting system control information in the downlink.
- Paging Control Channel (PCCH), for transferring paging information in the downlink (used when the network does not know the cell location of the UE, or, the UE is in cell-connected state).
- Common Control Channel (CCCH), for transmitting control information between the network and UEs in both directions (commonly used by UEs having no RRC connection with the network and by UEs using common transport channels when accessing a new cell after cell reselection).
- Dedicated Control Channel (DCCH). Point-to-point bi-directional channel for transmitting dedicated con-

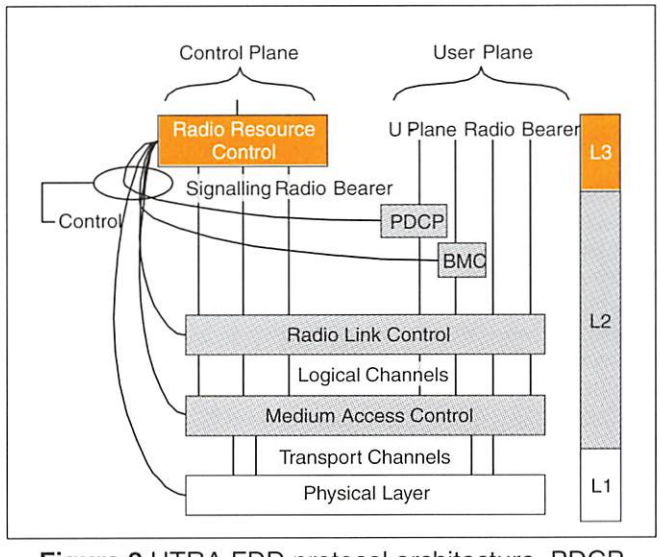

Figure 2 UTRA FDD protocol architecture. PDCP stands for Packet Data Convergence Protocol, BMC for Broadcast/Multicast Control Protocol.

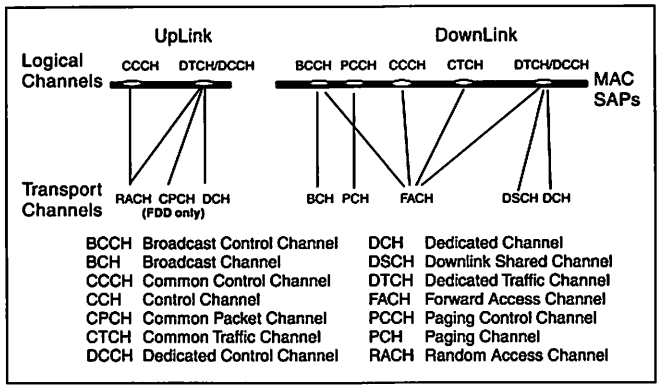

Figure 3 Mapping between logical channels and transport channels, in the uplink and downlink directions (for UTRAN FDD only, i.e. without Uplink Shared)

trol information between the network and a UE (established through RRC connection set up procedure).

- ✦ Dedicated Traffic Channel (DTCH). Point-to-point channel, dedicated to one UE for the transfer of user information (a DTCH can exist in both uplink and downlink directions).
- ✦ Common Traffic Channel (CTCH). Point-to-multipoint unidirectional channel for transfer of dedicated user information for all or a group of specified UEs.

The mapping between logical channels and transport ones is depicted in Figure 3.

In UTRAN the data generated at higher layers is carried over the air interface using transport channels mapped onto different physical channels. The physical layer has been designed to support variable bit rate transport channels, to offer bandwidth-on-demand services, and to be able to multiplex several services with different quality requirements within the same RRC connection into one Coded Composite Transport Channel. A CCTrCH carries the data being mapped to it by higher layers and the CCTrCH itself is carried by one physical control channel and one or more physical data channels. There can be more than one downlink CCTrCH, such as DCH and DSCH in parallel to one user, but only one physical control channel is transmitted on a given connection [3]. Use of multiple DCHs on one connection is not allowed.

The DCH can be used for any type of the service up to 2 Mbps, and it has a fixed Spreading Factor (SF) in the downlink. The DCH is fast power controlled and may be operated in macro diversity as well.

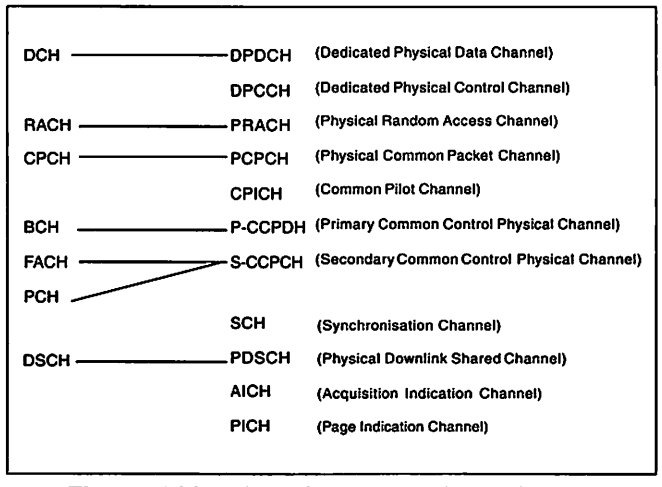

Figure 4 Mapping of transport channels onto physical channels

RACH carries uplink control information, such as a request to set up a radio resource control (RRC) connection. It is further used to send small amounts of uplink packet data. It is mapped onto the Physical Random Access Channel (PRACH). The RACH is intended for short duration 10/20 ms packet data transmission in the uplink. There exists also another uplink option, named Common Packet Channel (CPCH) to enable longer packet bursts up to 640 ms with power control, but that is not foreseen to be part of the first phase WCDMA network deployment nor the terminal implementations. CPCH supports uplink inner loop PC, with the aid of a downlink Dedicated Physical Control Channel (DPCCH). Its transmission may span over several radio frames and it is mapped onto the Physical Common Packet Channel (PCPCH).

BCH is used to transmit information (e.g. random access codes, cell access slots, cell type transmit diversity methods, etc.) specific to the UTRA network or to a given cell; is mapped onto the Primary Common Control Physical Channel (P-CCPCH), which is a downlink data channel, only.

The FACH can be used for downlink packet data as well. The FACH is operated on its own, and it is sent with a fixed spreading factor and typically with rather high power level since it does not support fast power control as power control feedback in the uplink is not available. FACH does not use soft handover. The uplink counterpart for FACH is RACH.

PCH carries data relevant to the paging procedure. The paging message can be transmitted in a single or several cells, according to the system configuration. It is mapped onto the Secondary-CCPCH.

The DSCH has been developed to operate always together with an associated DCH. This allows defining the DSCH channel properties to be best suited for packet data while leaving the data with tight delay budget to be carried by DCH. The DSCH in contrast to DCH has dynamically varying spreading factor informed to the terminal on a 10 ms frame-by-frame basis with physical layer signalling carried on the DCH. This allows dynamic multiplexing of several users to share the DSCH code resource and thus optimising the orthogonal code resource and base station hardware usage in the downlink. DSCH can utilize power control based on the associated DCH. DSCH is not operated in soft handover.

The WCDMA protocol and channels structures are designed to maximise the capacity utilisation. By assigning a service request to an optimum physical channel resources can be effectively allocated and shared.

The Key physical layer parameters are summarised in Table 1 based on the Release'99 WCDMA specifications.

Physical layer parameter	Alternatives
Chip rate	3.84 Mcps
Carrier spacing (nominal)	5 MHz
Carrier raster	200 kHz
Modulation uplink/downlink	Dual-channel QPSK/QPSK
Channel coding	Convolutional or Turbo coding
Frame length	10 ms
Interleaving length	10, 20, 40 or 80 ms
Spreading factors uplink/downlink	4-256/4-512
Power control command rate	1500 Hz
User data rate range with ½ rate coding	0-2.8 Mbps (Terminal capability)

***Table 1** Key WCDMA physical layer parameters*

4. Radio Resource Management

Radio Resource Management (RRM) consists of all functionality which is handling the air interface resources of a radio access network. These functions together are responsible for supplying optimum coverage, offering the maximum planned capacity, guaranteeing the required quality of service (QoS) and ensuring efficient use of physical and transport resources. RRM consists of power control (PC), handover control (HC), congestion control (typically subdivided into admission control AC, load control (LC) and packet data scheduling and the resource manager (RM). The actual RRM algorithms are not standardized, guidelines for RRM design can be found example in [5] and [6].

4.1 Power control

The purpose of power control is to ensure that each user in the network receives and transmits just enough energy to convey information while interfering with other users no more that necessary. This is critical from the network capacity point of view. A secondary advantage is, that the battery consumption of the MS is minimised. For the WCDMA standard the power control is applied in uplink and in downlink as well.

When the MS initiates a call, it adjusts its transmission power based on the received pilot signal power. The pilot signal is a cell specific signal broadcast in every cell with constant power. This provides a rough measure of the propagation loss between the MS and the BTS. The stronger the received pilot signal power is, the less transmission power is needed. This type of initial power adjustment is arranged by *open-loop power* control. The process has to be supported by a priori information which mobile receives on BCH broadcast in the cell. To set up a connection also other control channels are required to be used.

The variations in the multipath channel may cause that a fixed target E_b/I_0 or target SIR value cannot always guarantee a satisfactory bit error rate. Therefore the target must be controlled based on the achieved bit error rate or frame error rate. If the error rate is too high the target is increased until the desired error rate is met. Increasing the target for the uplink causes the closed-loop power control to lift the transmit power of MS until the new target is reached. The controlling of the E_b/I_0 or SIR target is named outer-loop power control.

The wideband signal in uplink and downlink is subject to fast fading, which is caused by the multipath channel. Thus, an additional mechanism called *closed-loop power control* is needed. In closed loop power control of the transmitted power of the MS is adjusted based on the received power measurement at the BTS. BTS compare the received energy per bit to interference energy ratio Eb/I0 to a target value and command the MS to increase or decrease its power accordingly. The same process is performed in the downlink direction. More details of the power control mechanisms can be found for example in [1] and [4].

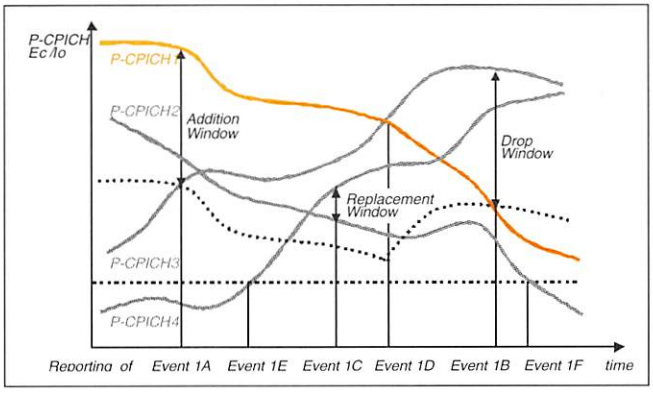

Figure 5 WCDMA handover algorithm with responding events 1A-1F [7]. The lower dotted line represents an absolute threshold, see description of event 1F. The higher dotted line is indicating the reporting range, which is relative to the strongest cell in the active set (AS).

4.2 Handover control

The Handover Control (HC) of the WCDMA supports different types of handovers and handover procedures. The HC can be divided into the following handover types:

- Intrasystem HO occurring within a WCDMA system. It can be further subdivided into Intra-frequency HO between cells belonging to the same WCDMA carrier.
- Inter-frequency HO between cells operated on different WCDMA carriers.
- Intersystem HO taking place between cells belonging to two different radio access technologies (RAT) or different radio access modes, like FDD-WCDMA to TDD-WCDMA. The most frequent case for the first type is expected between WCDMA and GSM/EDGE systems.

Furthermore the following HO procedures can be identified:

- Hard handover (HHO), a category of HO procedures, where all old radio links a MS is having are released before the new radio links are established. For real time bearers it means a short disconnection of the bearer, for non-real time bearers HHO is loss less.
- Soft (SHO) and softer HO are a category of HO procedures where a MS always keeps at least one radio link to the UTRAN. During *SHO* a MS is *simultaneously* controlled by to 2 or more cells belonging to different BTSs of the same RNC (intra-RNC SHO) or different RNCs (inter-RNC SHO). In *softer* HO a MS is controlled by at least 2 cells under one BTS. SHO and softer HO are only possible within one carrier frequency.

4.2.1 Soft handover

SHO is a general feature in systems like WCDMA, where neighboring cells are operated on the same frequency. When in connected mode, the mobile station continuously measures serving and neighboring cells (cells indicated by the Radio Network Controller, RNC) on the current carrier frequency. The mobile station compares the measurement results with HO thresholds provided by the RNC, and sends a measurement report back to the RNC when the reporting criteria are fulfilled. SHO therefore is a mobile evaluated handover. The decision algorithm of SHO however is located in the RNC. Based on the measurement report received from the mobile the RNC orders the mobile station to add or remove cells from its active set. HC of the UTRAN supports all described types SHO for both real time (RT) and non-real time (NRT) radio access bearers. In the WCDMA system the vast majority of handovers are intra-frequency handovers. Different types of intra-frequency handovers can take place simultaneously. For example, the RAN is able to perform soft (intra-RNC as well as inter-RNC) and softer handovers at the same time.

Intra-frequency measurement reporting can be either event triggered or periodic. During connected mode, the mobile station constantly monitors the P-CPICH E_c/N_0 of the cells defined by the intra-frequency neighbor list and evaluates the reporting criteria. In case one of the reporting events is fulfilled, the mobile sends an event triggered measurement report. Before the P-CPICH E_c/N_0 of a cell is used by the HO algorithm in the MS, an arithmetic mean over certain number of the latest measured values is taken. The number of the values taken into account is a MS performance specification pa-

rameter.. For intra-frequency measurement criteria, following reporting events are defined by [7]. Figure 5 shows an example for the general WCDMA HO algorithm involving all reporting events 1A-1F. In the example, the reports are sent as soon as the event is triggered, i.e. the time-to-trigger method is not used. Also there are no hysteresis values involved and the weighting coefficient is assumed to be zero.

Event 1A: A primary common pilot channel (P-CPICH) enters the reporting range.
The report is triggered when the measurement result of a cell comes within a set value, the addition window, of a weighted combination of the sum of all the measurement results in the active set (AS), and the measurement result of the strongest cell in the AS. The addition window is the sum of the hysteresis for event 1A and the reporting range, which is sent along with the weighting parameter from the RNC to the UE.

Event 1B: A P-CPICH leaves the reporting range.
The hysteresis together with the reporting range is usually called drop window.

Event 1C: A non-active P-CPICH becomes better than an active one.
This event is triggered when a P-CPICH which is not in the active set gets better than the worst P-CPICH from the AS when the AS is full. This event is used to replace the cell with the worst P-CPICH. If this event is equipped with a hysteresis, usually called replacement window, then the new cell has to be better than the worst cell by this value.

Event 1D: Change of best cell. This reporting event is triggered when any of the P-CPICHs in the reporting range is becoming better than the current best one plus an optional hysteresis value.

Event 1E: A P-CPICH becomes better than an absolute threshold.

Event 1F: A P-CPICH becomes worse than an absolute threshold.

The main objectives of the soft/softer handover are the following:

- Optimum fast closed loop PC, as the terminal is always linked with the strongest cells.
- Seamless handover without any disconnection of the radio access bearer.
- To enable a sufficient reception level for maintaining communications by combining the received signals (macrodiversity) at symbol level from multiple cells in cases when the mobile station moves to the cell boundary areas, and cannot obtain a sufficient reception level from a single cell.

Furthermore, the macrodiversity gain achieved by combining the received signal in the base station (softer handover) or in the RNC (SHO), improves the uplink signal quality and thus decreases the required transmission power of the mobile station.

4.2.2 Hard handovers

Inter-frequency HO (IF-HO) is a hard handover between different WCDMA carriers required to ensure HO path from one cell to another cell in situations when different carriers have been allocated to the cells in question. Also here HHO means that IF-HO causes temporary disconnection of the real time (RT) radio access bearer and is loss less for non real time (NRT) bearers. IF-HO also enables HOs between separate layers of a multi-layered cellular network, for example a network consisting of macro- and microcells where the cell layers are using different carriers The HC of the RAN should support following types of IF-HO:

- Intra-BTS hard handover (to control load between carriers)
- Intra-RNC hard handover
- Inter-RNC hard handover

Intersystem handover (IS-HO) is a handover between (FDD-) WCDMA and a neighbouring system using a different radio access technique (RAT) or also within WCDMA if the other system uses a different radio access method, i.e. TDD-WCDMA. IS-HO is required e.g. to complement the coverage areas of WCDMA and a neighbouring system with each other when the coverage area of WCDMA is limited only to certain areas. When the coverage areas of WCDMA and the neighbouring system are overlapping each other, an IS-HO can be used also to control the load between the systems. For example, speech connections can be handed over to a neighbouring 2G system and data connections can be handled within the WCDMA system. IS-HO is a hard handover, that is, an IS-HO causes temporary disconnection of the RT radio access bearer. When a RT radio access bearer is handed over from one system to another, the core network is responsible for adapting the QoS parameters included in the radio access bearer (RAB) attributes (see [11]) according to the new system. 3GPP specification work provides smooth interworking with the GSM/EDGE networks including common core network, multimode terminals, inter-system handovers and harmonized QoS parameters. The interworking is illustrated in Figure 6.

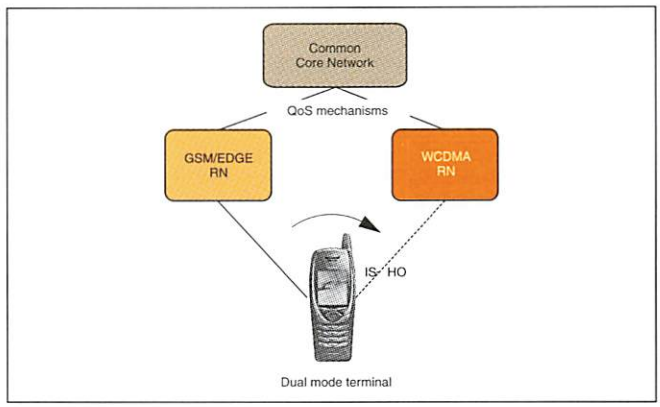

Figure 6 Harmonized GSM/EDGE and WCDMA standards for QoS continuation

IF-HO and IS-HOs are network evaluated handovers (NEHO) since the evaluation algorithm is located in the RNC.

4.3 Congestion control

In WCDMA it is important to keep the air interface load under predefined thresholds in order to meet the quality of service (QoS) targets. Three different functionalities are part of the congestion control:

Admission control handling all new incoming traffic. It is checking, whether a new packet or circuit switched RAB can be admitted to the system and produces the parameters for the newly admitted RABs.

Packet scheduling which is handling all the non-real time traffic, i.e. packet data user. Basically, packet scheduler is determining the time a packet transmission is initiated and which bit rate is used.

Load control, taking care of the situation that system load has exceeded the threshold(s) and some counter measures have to be taken to get the system back to a feasible load.

4.3.1 Admission control

The AC algorithm estimates the load increase, which the establishment or modification of the bearer would cause in the radio access network. Both uplink and downlink direction are estimated separately. Only if both uplink and downlink admission criteria are fulfilled the bearer setup or modification request is accepted, the RAB is established or modified or the packets are sent. Load change estimation can be improved by taking the intercell interference effect into account. The bearer is not admitted if the predicted load exceeds particular thresholds either in uplink or downlink. In the decision procedure the AC will use thresholds verified during radio network planning. Two approaches for admission control can be identified: power based and throughput based. In the power based AC case the uplink interference and downlink transmission power information received from the wide band channel are used in the decision making. In the throughput based case the current uplink and downlink throughput is of interest. To be able to decide whether the AC accepts the request, the current load situation of the surrounding cells in the network has to be known and the additional load due to the requested service has to be estimated. Therefore the AC functionality is located in the RNC where all this information is available.

In power based AC case a RT bearer would be admitted, if the non-controllable uplink load, PrxNC, fulfils Equation (1) (where ΔI is estimated change in interference if a new user would be admitted) and the total received wideband interference power *PrxTotal* fulfils Equation (2).

$$PrxNC + \Delta I \leq PrxTarget \quad (1)$$

$$PRXTotal \leq PrxTarget + PrxOffset \quad (2)$$

where PrxTarget is a threshold and PrxOffset is an offset thereof, defined during radio network planning phase. For NRT bearers only the latter condition is applied. The non-controllable received power, PrxNC, consists of the powers of RT users, other-cell users, and noise. ΔI is the increase of wideband interference power (uplink), which the admission of the new bearer would cause. Similar logic can be applied for downlink case. Details on power increase estimation can be found for example in [8].

4.3.2 Packet scheduling

WCDMA packet access is controlled by the packet scheduler, which is part of the radio resource management functionality in RNC. The functions of packet scheduler are:

- determine the available radio interface resources for non-real time radio bearers
- share the available radio interface resources between the non-real time radio bearers
- monitor the allocations for the non-real time radio bearers
- initiate transport channel type switching between common, shared and dedicated channels when necessary
- monitor the system loading
- perform load control actions for the non-real time radio bearers when necessary. As shown in Figure 7, AC and packet scheduler both participate in the handling of NRT radio bearers.

AC takes care of admission and release of the radio access bearer. Radio resources are not reserved for the whole time of a connection but only when there is actual data to transmit. Packet scheduler allocates appropriate radio resources for the duration of a packet call, i.e. active data transmission. As shown in the figure, short inactive periods during a packet call may occur, due to bursty traffic.

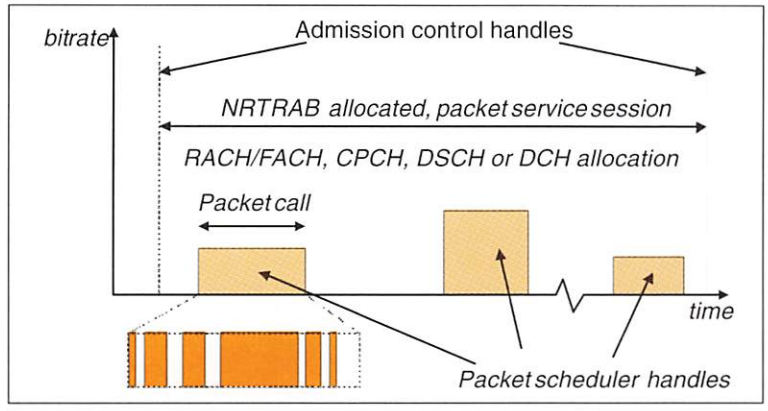

Figure 7 Admission control and packet scheduler handle non-real time radio bearers together

The packet scheduling is done on cell basis. Since the asymmetric traffic is supported and the load may vary a lot between uplink and downlink, capacity is allocated separately for both directions. However, when dedicated channel is allocated to one direction, it also has to be allocated to other direction as well, even if the capacity need was triggered only for one direction. Packet scheduler allocates dedicated channel with low data rate for other direction, which carries higher layer (TCP) acknowledgements, data link layer (RLC) acknowledgements, data link layer control and power control information. This low bit rate channel is typically referred as 'return channel'.

Radio resources of the cell are shared between real time and non-real time radio bearers. The proportion between real time and non-real time traffic varies rapidly in time. It is characteristic of real time traffic that the load caused by it cannot be controlled in efficient way. Load caused by real time traffic, interference from other cell users and noise together is called non-controllable load. The available capacity, which is not used for non-controllable load, can be used for non-real time radio bearers on best effort basis, as shown in Figure 8. The load caused by best effort non-real time traffic is called controllable load.

Usually non-real time users use the resources left from real time users, since the scheduling of non-real time radio bearers happens on best effort basis. It is however possible to configure dedicated resources for the non-real time radio bearers, by using separate load targets for real time and non-real time users, which are considered in admission control.

4.3.3 Load control

The main functionality of the Load Control (LC) can be divided into two tasks. In normal circumstances LC takes care

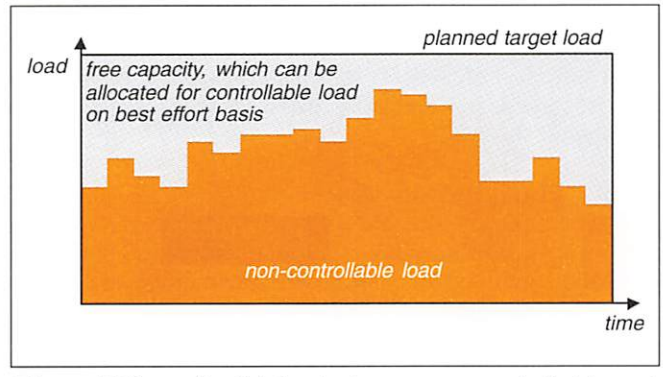

Figure 8 Capacity division between non-controllable and controllable traffic

that the network is not overloaded and remains in a stable state. To achieve this LC works closely together with AC and packet scheduler. This task is called preventive load control. In very exceptional situations however the system can be driven into overload situation. Then the overload control is responsible to reduce the load relatively fast and thereby bring the network back into the desired operating area defined by radio network planning. The load control functionality is distributed between BTS and RNC.

4.4 Resource manger

The main function of the resource management (RM) is to allocate physical radio resources when requested by the RRC layer. To be able to do this the RM has to know all the necessary radio network configuration and state data including the parameters affecting the allocation of logical radio resources.

The RM is located partly in the RNC and partly in the BTS. It works in close co-operation with the AC and the packet scheduler: the actual input for resource allocation comes from the AC /packet scheduer and RM informs the packet scheduler about the resource situation. In the channel allocation the RM attaches a certain channelisation code for each connection in downlink direction – the length of the spreading code depends on the available codes at that moment and the requirement for data rate in the channel request; the higher the rate the shorter the code. The RM has to be able to switch codes and code types because of different reasons, e.g. SHO, defragmentation of code tree etc. The RM is responsible also for the allocation of scrambling codes for uplink connections. And obviously the RM has to be able to release the allocated resources as well.

5 QoS Mechanisms

In the context of UMTS networks, Quality of Service (QoS) refers to the collective effect of service performances that determine the degree of satisfaction of the end-user of the service [9]. The QoS architecture consists of all the UMTS network functions that participate in providing the end-user the appropriate service quality. The QoS mechanisms within the UMTS network are standardised in 3GPP, which also defines the interworking of the UMTS QoS mechanisms and the QoS mechanisms used in the external networks. Specification [11] defines the QoS concept within the UMTS network while [12] provides a framework for end-to-end QoS between the UE and the remote end-point outside of the UMTS network. [11] covers both the Packet Switched and the Circuit Switched sides of the UMTS core network. [12] deals only with the Packet Switched Core network.

The QoS architecture of the UMTS is depicted in Figure 9. It is logically divided into layers and bearer services. Each bearer service of the upper layer consists of the bearer services of the lower layers. The end-to-end IP bearer shown in

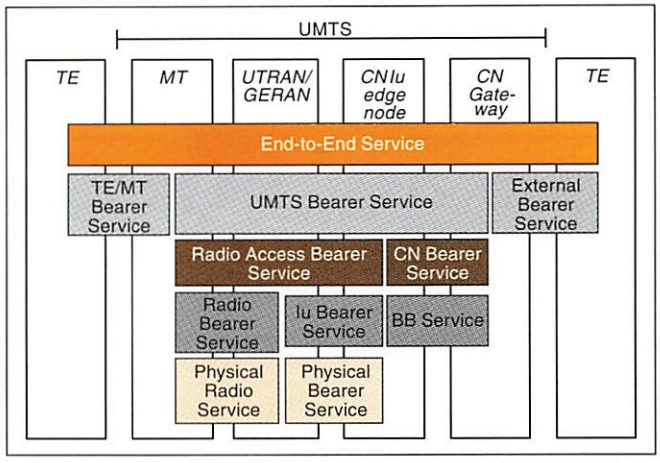

Figure 9 UMTS QoS Architecture [11]. TE stands for terminal equipment, BB for back bone and MT for mobile terminal

Figure 9 is one example of an end-to-end service. Within the UMTS network the UMTS bearer service consists of the Radio Access Bearer (RAB) service and the Core Network (CN) Bearer service. The UTRAN and GERAN are responsible for the Radio Bearer Service and the Iu Bearer Service. The serving GPRS support node (SGSN), GGSN and the possible IP based network between those network elements provide the CN Bearer Service.

Within the 3GPP specified Radio Access and Core Networks, QoS provision and resource reservation are based on the PDP-context activation. Every PDP context is associated with a set of QoS attributes to be negotiated in conjunction with the context activation procedure. The set of QoS attributes is referred to as a QoS Profile. It includes those essential parameters for the application to describe the QoS need of its media streams, for example, traffic classes, target transfer delay, reliability, guaranteed bit rate, and priority, etc. This QoS profile is negotiated during the PDP context activation procedure. It describes the quality the UMTS bearer service offers to the user. 3GPP supports multiple PDP contexts of the same IP address with different QoS requirements. This enables a multimedia session to describe the QoS needs of individual media stream. One UMTS bearer equals to one PDP context.

5.1 UMTS traffic classes

The UMTS bearer services are categorized into four traffic classes as shown in Table 2. The main distinguishing factor between these classes is the delay sensitiveness of the expected traffic: the Conversational class is meant for the most delay-sensitive real-time (RT) applications while the Background class is expected to be used by applications having very loose delay requirements. The most typical exam-

***Table 2** UMTS traffic classes [11]*

Traffic Class	Conversational RT	Streaming RT	Interactive NRT	Background NRT
Fundamental characteristics	Preserve time relation between information entities of the stream Conversational pattern (stringent and low delay)	Preserve time relation between information entities of the stream	Request-response pattern Preserve payload content	Destination is not expecting the data within a certain time Preserve payload content
Example of the traffic source	Voice	Streaming video	Web browsing	Background download of emails

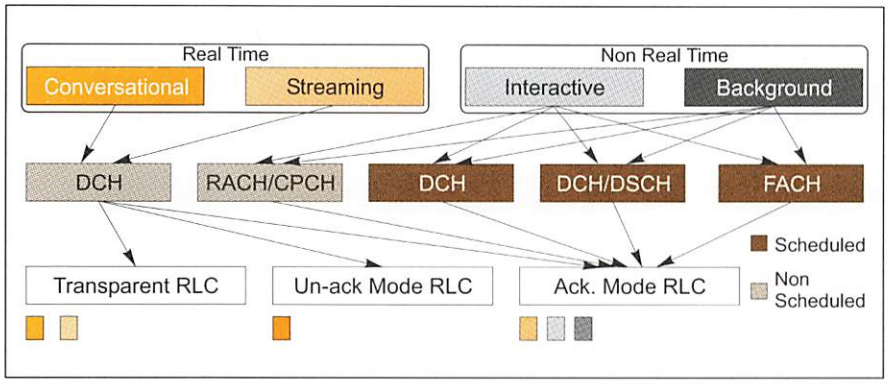

Figure 10 Radio Bearer mapping of UMTS traffic to physical channels [4]. Figure is based on the matching between the radio bearer capability and the required UMTS bearer QoS. All of the traffic classes can be transferred in more than one way depending on the QoS parameters and operator definable network planning parameters

ple of conversational class is the Adaptive Multi-rate (AMR) coded speech, which is the mandatory codec used in WCDMA terminals, for more details see [13].

In addition to the traffic classes, other QoS attributes have been defined in order to enable more enhanced service differentiation for the UMTS bearers. QoS attributes include items like traffic handling priority (THP), allocation retention priority (ARP), guaranteed bit rate and transfer delay (for RT). These attributes being important in the differentiation process. The traffic class attribute has, however, a specific role because it specifies the other QoS attributes, which are allowed to be used in the corresponding QoS profile, for more details see [11]. The traffic classes are applicable for User Plane (UP) traffic, this includes also transport layer protocols, application layer call control protocols, application layer QoS control protocols and IP bearer QoS control protocols. All these protocols use the UMTS bearer services and thus belong to the UP traffic. An overview of the Control Plane (CP) is given in [14].

5.2 QoS in radio access

There are three fundamental aspects of how QoS differentiation and optimization can be provided over the WCDMA radio interface:

- mapping of the UMTS QoS parameters to radio transport and physical channel characteristics (call quality), see Figure 10.
- priority in the bearer admission and scheduling decisions
- optimization of the perceived QoS in terms of service availability (service coverage and capacity).

In UTRAN, radio QoS control is provided by the Radio Resource Management (RRM) in the Radio Network Controller (RNC), using a toolbox functionality consisting of

- Admission Control
- Load Control
- Handover Control
- Power Control
- Packet Scheduler

The fundamentals of admission control and packet scheduling was discussed in Section 4.3. Since the main criteria in a WCDMA system for radio resources is interference, the load control function relies on monitoring both uplink and downlink interference periodically on cell basis. The proportion between Real-Time (RT) and Non-Real Time (NRT) traffic varies all the time. Admission Control algorithm estimates the uplink and downlink load increase caused by the establishment or modification of a Radio Access Bearer (RAB), and make decisions accordingly. The load change is dependent on the attributes of the RAB, the traffic class, and the requested QoS parameters such as bit rate, delay and loss rate. The QoS differentiation in admission phase is visible during RAB queuing, which can be done based on priorities allocated by core network (CN). Further, the possibility to reserve some of the resources for NRT traffic only, is part of the RAN QoS differentiation mechanisms. In the case of NRT data, the CN priorities are used when performing the allocation.

In the case of congestion in the RAN load control will take over. Due to the very nature of packet scheduling, NRT traffic will naturally experience longer delay if the cell congested. The RT calls should not experience any blocking or service downgrading unless the aggregated RT load in the cell exceeds the allowed load threshold. In order to maintain the quality of on going RT calls, a handover to other frequency, radio layer, or system is initiated. Further, service downgrading (for example, bit rate reduction) can be realized using transport channel reconfiguration procedure, in order to reduce the congestion in the network.

In terms of the perceived service quality, good radio coverage (accessibility and connection reliability) is very important, as well as the optimized capacity providing low blocking probability and high throughput. Optimization of coverage and capacity can be found in detail in [4] and [15].

6 Evolution of WCDMA RAN

The Release 5 specifications contain downlink packet data operation enhancement, HSDPA which utilizes Hybrid ARQ higher order modulation and Node B scheduling for improving downlink data spectral efficiency and for pushing bit rates beyond 10 Mbps.

WCDMA evolution for Release 6 and further releases is continuing with the following key areas being worked in 3GPP standardisation. The topics include:

- Enhanced uplink dedicated channel, which focuses to study methods used in the HSDPA feature to achieve performance improvements in the downlink direction. The uplink direction has different restrictions than the downlink direction. In the uplink there is no code shortage but the terminal power is limited and controlling the uplink noise rise is the key to improved capacity. WCDMA contains already in Release'99 advanced features related to the uplink packet data operation, such as RNC based uplink scheduling functionality as well as measurements that facilitate the scheduling. Figure 11 illustrates an example of the concept being studied for the uplink enhancements in 3GPP. It is expected that there will be new physical layer signalling added between the Node B and the User Equipment (UE).
- New frequency variants of WCDMA, such as the utilization of 2.5 GHz spectrum and 1.7/2.1 GHz.
- Advanced antenna technologies [16], including enhancements for the beam forming capabilities in the network side for the support of radio resource management as well as transmit diversity technologies with single terminal receiver antenna or with two receiver

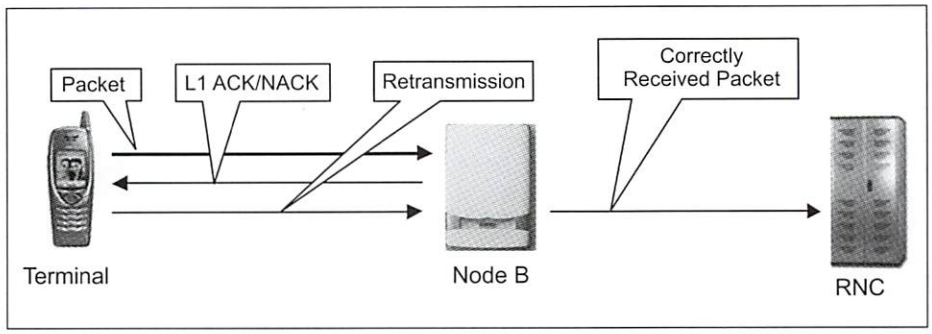

Figure 11 Release 6 study item, "Enhanced uplink DCH" with proposed Node B based operation for HARQ in the uplink

antennas in the terminal. The latter work is carried under the multiple input multiple output (MIMO) term.

- The support for Multimedia Broadcast and Multicast Service (MBMS) which is as such a service driven topic but discussion has been initiated in standardisation whether there should be some further enhancements in the radio access side to support the service more efficiently.
- In the area of UTRAN architecture evolution, the work has been initiated to study distributed architecture option that could enable more efficient use of IP technology as the transport technology as well as further evolution of the radio resource management functionalities in the radio access network.

7 Core network issues

The core network to be operated with WCDMA in Release'99 is basically the same as has been used with GSM previously. In Release 4 the MSC split was introduced with introduction of the MSC server and the Media Gateway (MGW). The next significant step is the introduction of the IP Multimedia Subsystem (IMS) in Release 5. The IMS enables to provide standardised multimedia services from the PS-domain of the core network, with further work being carried out to allow basically providing of all the desired services via PS-domain. The simplified picture of the Release 5 core network structure is shown in Figure 12, with the simplification that the control connections to the registers contained in Home Subscriber Server (HSS) are now shown. The IMS specific functions are located in 3 separate units in Figure 12. The IMS functions shown are:

- Media Resource Function (MRF), which among other tasks controls media stream resources
- Call Session Control Function, which acts as the proxy for the terminal in IMS.
- Media Gateway Control Function (MGCF) handling e.g. protocol conversions

8 Conclusions

In this paper, the WCDMA radio access basics and first evolution steps were briefly presented. The WCDMA technology offers a wide range of possibilities for service introduction, including means for providing different service qualities and multiple services in parallel. The radio access network architecture has been shaped by the CDMA principles and 3GPP standardisation has provided multivendor capable interfaces not only to the core network but also inside the radio access network. The first step in WCDMA in the form of HSDPA has boosted the capacity further and work is on-going to explore potential of the further enhancements of the technology.

The mobile future is very much about services. The bravest statements claim that what ever can be digitised will be transmitted via air. The other aspect in the mobile future is the service and customer differentiation. The framework provided by 3GPP provides good mechanisms to support this. The end-to-end control for service provisioning and differentiation will not only change the end user experience, but it will cause a change in operators' and vendors processes and future.

Acknowledgements

The authors wish to thank John Wiley and Sons for permission to reuse material from References [1] and [4].

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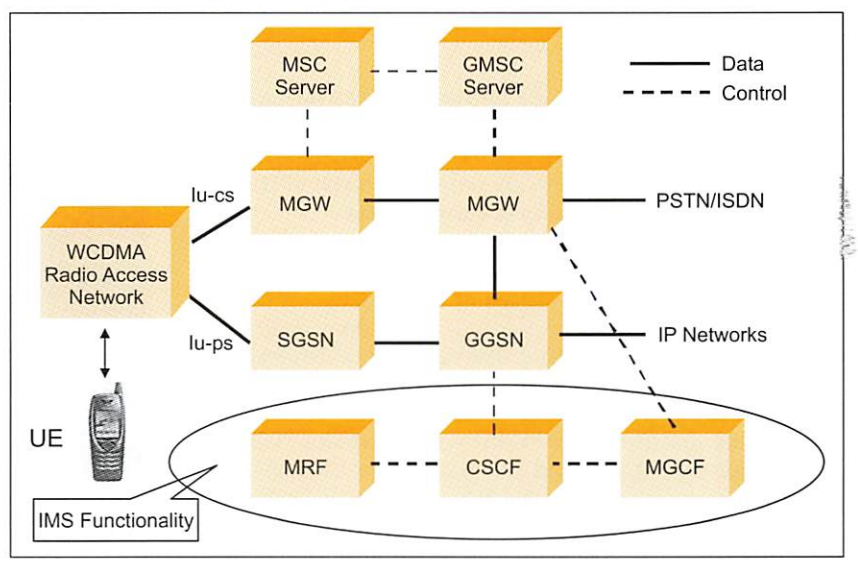

Figure 12 Release 5 WCDMA core network

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Transportation Systems

Harvey Glickenstein, Senior Editor

Shanghai has awarded a contract for 60 metro cars to a joint venture of Bombardier and Changchun Car Company of Changchun, China. The cars will be built in Changchun, approximately 500 miles northeast of Beijing. They will be supplied in ten six-car trainsets.

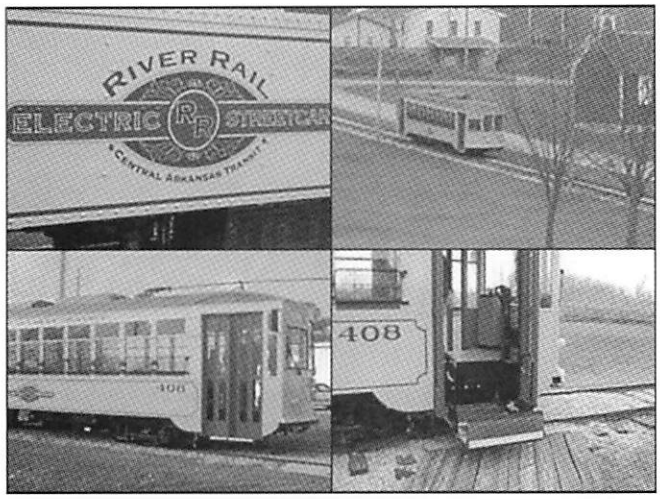
The cars will feature modular aluminum carbodies. The propulsion equipment will come from Sweden and some of the trucks will be manufactured in Derby, UK.

The $C121 million order is split 64% for Bombardier and 36% for their Chinese partner. The cars will be delivered between June 2004 and May 2005 and will operate on Shanghai Metro Line 1.

The joint venture had previously received orders for 156 vehicles for Guangzhou and 132 vehicles for Shenzhen.

The first streetcar for the River Rail Streetcar line of Central Arkansas Transit was tested in Mt. Pleasant, Iowa. The car is scheduled to be shipped to North Little Rock late spring this year. It is a replica of a double truck

Artist Impression of Shanghai metro car



River Rail Street Car

Birnie streetcar that ran in Little Rock and North Little Rock from the 1920s through 1947.

In accordance with current American with Disabilities Act requirements, the new car is equipped with a wheelchair lift.

California will have High Speed Rail on the ballot in November. Governor Gray Davis signed the Safe, Reliable High-Speed Train Bond Act of the 21st Century in September 2002. The bill places a $9.95 billion general obligation bond on the ballot. About $1 billion of the bond issue would go toward intercity rail, commuter rail, and urban rail passenger services throughout the state.

A key feature of the bill extends the charter of the High Speed Rail Authority beyond its previous termination date of December 2003.


Alstom's new cars for Barcelona

The draft business plan issued by the High Speed Rail Authority envisions a 700-mile, $25 billion high-speed rail system linking Sacramento, Merced, Bakersfield, Los Angeles, San Diego, and the San Francisco area. The high-speed rail system would operate at speeds of 200 mph or more.

Expansion of the Salt Lake City TRAX light rail system was endorsed by the city council of West Valley City in a six to one vote. Although the Utah Transit Authority (UTA) did not require endorsement of the city council to apply for federal funds for the proposed five-mile extension, the endorsement of the city council was hailed by the UTA.

The $220 million expansion would stretch west from the end of the north-south line through several business parks and residential neighborhoods before turning south to Valley Fair mall and City Hall. An environmental impact statement will need to be completed before the extension goes forward.

Hamburg, Germany has awarded a contract to a joint venture of Alstom and Bombardier for 60 subway cars. The DT4 cars will be delivered in fifteen trainsets of four cars each. The new cars will be delivered from March 2004 through April 2005. They are a follow-on order to 126 vehicles ordered from the same consortium of which 92 vehicles had been delivered through the end of last year.

The Toronto Transit Commission opened its first new subway line since 1966 in November of last year. Groundbreaking for the Sheppard Subway from Yonge Street to Don Mills Station took place in 1994. The line is four miles long.

Barcelona ordered 250 new cars from Alstom for their new fully automated Line 9. The new line will be 25 miles long and have 43 stations. It will be the longest line in Barcelona, running from the north side to the south side and the airport.

The cars will be delivered in fifty trainsets of five cars each. Delivery will start in October 2004 and be completed by April 2007.

The first section of Delhi's metro opened on Christmas Day. The 8.3km stretch of Line 1, constructed to India's standard broad gauge, includes 6 stations. The metro has proved very popular, with over a million people attempting to use the system on the first day. Phase 1 of the system, to be complete by 2005, includes just over 60km of an eventual 200km envisaged by 2021.

VTS - May Technology-Sharing Forum May 1, 2003, 6:00 to 8:00 PM

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New Rail Car Technology vs Maintenance
Dave Elliot, Long Island Railroad Project Manager for the Advanced M7 Rail Car Program
Learn how the M7's onboard Central Diagnostic System will change Rail Car Maintenance

Wireless Communications on Trains
Christopher Kolb of Cisco Systems
Learn of the current and future trends in wireless technologies and systems for the Rail Transit industry

Advance registration is required for admission, and both IEEE Members and non-members may register. There is a $35.00 charge for the forum and refreshments commencing 5:30 PM. $35.00 checks payable to IEEE NY Section. If you are an IEEE member, please provide your membership number.

Additional information regarding program specifics can be obtained by contacting Mr. Ramdane Benferhat at 718-243-4926 or by e-mail at rabenfe@nyct.com.
Mail To: Mr. Ramdane Benferhat
NYCT - Rail Transit Operations Support,
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Brooklyn NY 11201

Mobile Radio

Javier Gozalvez, Senior Editor

3G News

Mobilkom austria announced the start of 3G service in major parts of Austria. Service was inaugurated with a live streaming video call between the cities of Vienna and Graz. Approximately 25% of the country's population is covered in the initial 3G launch (11 cities). Content will initially be provided through a number of exclusive partnerships between mobilkom austria and for example the Austrian public broadcast station ORF, news agency Reuters and leading Austrian on-line sports media channel, sport1.at. The Austrian operator predicts that 40% of the nation's population will have access to UMTS services by the end of 2003.

J-PHONE has announced the launch of Vodafone Global Standard, a 3G service, based on international 3GPP standards. By using Universal Subscriber Identity Module ("USIM") cards, Vodafone Global Standard users will be able to roam internationally. J-PHONE's Vodafone Global Standard service will offer 3GPP-compliant high-quality voice telephony, high-speed data communications and videotelephony functions with coverage initially available in the Tokyo Metropolitan area and major cities nationwide. In the initial phase of service, three 3GPP 3G handsets will be rolled out, including the V-N701, a 3G (W-CDMA)/GSM dual mode handset. Meanwhile, NTT DoCoMo, in its report for the full fiscal year ending in March 2003, announced it is forecasting only about 320,000 FOMA (its 3G service) subscribers compared with its initial estimates of more than 2 million subscribers when it launched the service in 2001. On the other hand, the Japanese mobile operator KDDI has reported that its CDMA 3G customer base numbers over four million. The company also said it is on track to meet its target of 7 million 3G users by March 31, 2003.

Monet Mobile, a Seattle-based wireless Internet Service Provider, has launched the first commercial CDMA2000 1xEV-DO network in the United States. For a flat monthly rate, Monet Broadband offers high-speed, mobile access to the complete Internet, enabling streaming video, multimedia, position-location services, e-mail, and secure access to corporate intranets and databases. Monet's Broadband network is accessible through a modem card that is compatible with desktops, laptops and handheld PCs. Russia's Delta Telecom has announced the launch of its CDMA2000 1X network in the 450MHz frequency band. According to the company, this new network will be the first one in Russia capable of providing subscribers data services at speeds of up to 153 kb/s along with high-quality voice services. Telesp Celular and Telefónica Celular, two of the largest Brazilian mobile operators with a combined total of 13.5 million subscribers, have announced CDMA2000 1X network expansions in the country's southeastern region. Movilnet, a Cantv (ADR) company has commercially launched CDMA2000 1X services at a ceremony held in Caracas, Venezuela. EPM-Bogota of Colombia also commercially launched 3G services, based on CDMA2000 1X, through its AirNet service for the city of Bogota.

Portugal's EDP has decided to shut down its 3G operations subsidiary, Oniway, and sell off the company's assets. Oniway has already spent around $480 million in building its network and says that it will sell its infrastructure to the country's three other networks. Sweden's Tele2 has handed back its Norwegian 3G license and has completed an MVNO agreement with Telenor, which will provide UMTS access to Telenor's Norwegian network. Orange SA has announced its intention to withdraw from the Swedish market in direct response to the pressures placed upon it by the UMTS licence requirements and current market conditions. The Spanish Ministry of Science and Technology has decided to cut by about 86% the guaranteed cash deposits telecom companies were required to make for UMTS licenses. In exchange, the four Spanish UMTS operators have agreed to increase their investment in the technology a 20% for 2003. Vodafone Australia has outlined plans to try and share its 3G infrastructure with one or more rivals in the Australian market. According to the operator's chief operating officer they don´t expect to be four 3G networks in Australia. Hong Kong´s telecoms regulator has decided to waive the submission of performance bonds due in October 2002 from the four 3G license holders. This measure has been adopted in order to assist the industry in response to changing market conditions.

Lucent Technologies has announced that it is the first vendor in North America to complete CDMA2000 voice and high-speed data wireless calls for 2.1 GHz spectrum. According to the US manufacturer, these successful calls, completed at Lucent's Wireless Research labs, are a significant milestone in the development of CDMA2000 infrastructure for 2.1 GHz spectrum, which is being evaluated as an option for mobile operators to offer commercial service in China. Using a CDMA2000 2.1 GHz test terminal and Lucent's CDMA2000 infrastructure, Lucent demonstrated high-quality voice calls. In addition, high-speed mobile data services such as Web browsing and e-mail access were exhibited at data speeds of up to 153 kilobits per second when the test terminal was connected to a laptop.

Ericsson announced the first live, dual mode WCDMA/GSM calls with seamless handover between the two modes. The demonstration, which was performed for Telia and Hi3G (Hutchison Whampoa), also included high data rate in live WCDMA/GSM networks. Ericsson demonstrated WCDMA/GSM end-to-end calls using small-sized handsets in live networks with high-speed data rates up to 384 kbit/s. Allowing the user to seamlessly hand over calls between different networks is an important step in the 3G roll out. Handover makes it possible for incumbent operators to expand their 3G networks and offer consumers complete coverage right from the start by combining existing GSM network with the new WCDMA networks. Nokia also

announced it has performed successful voice call handovers between a live 3G WCDMA network to Vodafone Omnitel's commercial 2G GSM network in Italy. The handovers were completed using Nokia 6650 terminals and Vodafone Omnitel's existing GSM and WCDMA infrastructure. Moreover, the GSM network is being upgraded and tested to support such intersystem handovers (ISHOs) nationwide.

Ericsson and AT&T Wireless have completed what they claim is the first WCDMA/UMTS call in a live network environment in the Americas. With initial packet data speeds up to 384 kbps, the call demonstrates true 3G capabilities, which include quick downloads of such bandwidth-demanding applications as E-mail with attachments and streaming audio and video. The joint effort is part of a trial of the first 1900 MHz UMTS/WCDMA system in the Americas, which will have more than 100 cell sites in the Dallas area by the end of the year.

Nokia and Vodafone Omnitel have carried out what they claim is the world's first VoIP call completed in a 3GPP release 4 compliant network that transports circuit-switched voice and data calls through an IP backbone. The call was performed using the commercial Nokia MSC Server and Nokia Media Gateway products in laboratories in Helsinki. The unmatched benefit of the new core architecture is the separation of the control and routing functions into separate network elements. The MSC Server, which is sometime referred to as a mobile network "soft switch", performs the call-control and signaling function (called the "control plane"). MSC Server architecture implements new packet-switching and VoIP technology for mobile switching and transmission, and is based on the 3GPP release 4 standards. The routing function (called the "user plane") is handled by a separate network element, the Multimedia Gateway.

Nortel Networks and Qualcomm have completed what they claim is the industry's first UMTS voice and data calls demonstrating mobility across commercial cell sites using live 1900 MHz radio spectrum, Qualcomm chipsets in commercial-form-factor handsets, and a live, end-to-end 3GPP UMTS network from Nortel Networks. Nortel Networks has also demonstrated what it claims is the world's first UMTS calls using an IP-based UTRAN. The transmissions were made across a live, end-to-end UMTS network using form factor handsets and an IP backbone based on Nortel Networks Optical Ethernet equipment. The demonstration was provided at Nortel Networks Global Technology Center in Ottawa.

Fujitsu has announced it has begun providing a new base transceiver station equipment for DoCoMo's 3G network that has the capacity to handle more than 2,880 channels (it refers to the number of channels as defined by one channel per voice call), or quadruple the capacity of existing equipment. The equipment uses a high-speed channel signal processor and a high efficiency transmitter amplifier built with new distortion-compensation technology. These components enable a dramatic reduction in power consumption.

China's Huawei Technologies has launched what it claims is the world's smallest WCDMA Node B. The Huawei indoor macro-cell Node B is only 1.4 meter high and a single cabinet can support up to 12 carrier sectors, an equivalent of 16 GSM BTSs.

QUALCOMM has announced the availability of WCDMA test mobiles at 1900 MHz for North American test and deployment activities. These test mobiles are identical to those used for WCDMA in Europe and Asia except that the test phones' external radio frequency (RF) components are tuned to the 1900 MHz band instead of the 2100 MHz frequency used in Europe and Asia.

Nokia has announced the world's first 3GPP compliant mobile phone operating both in the GSM 900/1800 frequencies and on the WCDMA protocol. The dual-mode functionality makes the Nokia 6650 phone the world's first GSM/WCDMA handset to work in Europe and Asia including Japan.

Alcatel and O2 Germany have announced the signature of a frame agreement to build up a part of O2 Germany's nationwide backhaul transmission network infrastructure in Germany. Alcatel's microwave radio systems will connect the mobile base stations (Node B) and radio network controllers (RNC) of the O2 Germany UMTS network. Under the terms of the frame agreement, Alcatel will supply its plesiochronous digital hierarchy (PDH) low-to-medium capacity microwave radio systems, and synchronous digital hierarchy (SDH) radio equipment, suitable for deployment in both urban and regional areas.

Motorola's Global Telecom Solution Sector (GTSS) has announced it has shipped more than 30,000 CDMA2000 1X third generation base stations. Motorola has CDMA2000 1X contracts with 12 wireless operators worldwide. On the other hand, Ericsson announced it has shipped more than 10,000 commercial UMTS/WCDMA macro base stations. The operator said it has shipped to more than 35 customers in 24 countries.

NTT DoCoMo, Ericsson, Nokia and Siemens reached a mutual understanding to introduce licensing arrangements whereby essential patents for W-CDMA are licensed at rates that are proportional to the number of essential patents owned by each company. The intention is to set a benchmark for all patent holders of the W-CDMA technology to achieve fair and reasonable royalty rates. The companies together own the clear majority of the essential Intellectual Property Rights (IPR) relevant to the W-CDMA standard. As essential patent holders, Japanese manufacturers Fujitsu, Matsushita Communication Industrial (Panasonic), Mitsubishi Electric, NEC and Sony Corporation have also expressed their willingness to co-operate with such arrangements.

The 3rd Generation Partnership Project (3GPP) has approved its first 3GPP protocol test case written in Tree and Tabular Combined Notation (TTCN). This formally opens up the way for 3G terminal (or User Equipment (UE)) protocol conformance testing to begin. 3G system simulator manufacturers such as Anritsu and Rohde & Schwarz verified the test case on their protocol test systems with 3G terminals from Ericsson Mobile Platforms, Nokia and QUALCOMM. Motorola and Panasonic also confirmed that they had successfully run the same test case in their own laboratories. TTCN offers the industry a machine-readable language for defining conformance test requirements in a concise and unambiguous way. This in turn will lead to more consistency in testing results between test platforms and more reliable mobile devices for the subscriber.

Mobile Satellite Communications

Inmarsat has announced a hybrid satellite/cellular service that can deliver data at speed as high as 176kbps. The Regional BGAN service requires a satellite modem that can be used with laptop or desktop computers. The company said that 10 GSM carriers (none in the US) are offering the service.

The Ministries of Defence of France, Italy and the United Kingdom have jointly submitted an initial proposal to meet the NATO SATCOM Post-2000 capability requirement for

SHF and UHF space segment. As the current NATO IV satellites approach the end of their lives, NATO is now calling for a next generation solution to fulfill its ever-increasing milsatcom requirements. The SATCOM Post-2000 requirement will update both the space and ground segments to form the future NATO system. NATO's current procurement process entails the issue of separate Invitations for Bid (IFB) for the UHF, SHF and EHF space segment requirements. Final bids are due in Spring 2003.

The European Space Agency has awarded Alcatel Espacio and its industrial consortium the development and turnkey delivery of the Broadband Interactive Multimedia Communications System by Satellite, called AMERHIS, which will be on board the Amazonas satellite from Hispasat. AMERHIS is the first in the worldwide communications industry to offer bi-directional communications through satellite. The system core is based on a digital processor that provides a compatible interface with the new open standard DVB-RCS (Digital Video Broadcasting-Return Channel Satellite) for the return channel through satellite and the DVB-S consolidated standard for down link.

Alcatel has announced the signature of a contract with the China Academy of Space Technology (CAST) for the development and construction of the first high capacity Chinese telecommunications satellite. The new satellite, that will be delivered to APT (Hongkong), is tailored to provide communication, radio and TV broadcasting services to telecom operators and to radio and TV stations.

Technology and Research News

NTT DoCoMo has announced that it has succeeded with the 100Mbps-downlink and 20Mbps-uplink transmission experiment under an indoor environment using an experimental system for 4G mobile communications. 4G mobile communications systems require a bandwidth of approximately 100MHz. DoCoMo's experimental 4G system employs variable spreading factor (VSF) and orthogonal frequency code division multplexing (OFCDM) technologies to mitigate the impact of severe of severe multipath interference, and to allow flexible and fast packet transmission in compliance with area and other communications conditions.

DoCoMo has also announced that, together with HP, has developed the Mobile Streaming Media Content Delivery Network (MSM-CDN9, which they claim is the world's first technologies for a highly advanced multimedia delivery content suited specifically to 3G and future mobile communication services. A key feature of MSM-CDN is its delivery servers, which are optimized for effectively delivering content from the internet, especially streamed content, via mobile networks. In addition, management serversw monitor network traffic and delivery-server loads in the MSM-CDN.

The ITU has announced that the technical design of a new video compression standard, known as H.264/AVC has been agreed. The standard, that will published in Q2 of 2003, is likely to find use in a wide variety of applications from mobile phones to High Definition TV.

Lucent Technologies has announced that Bell Labs, its research and development arm, has designed two prototype chips for mobile devices that implement its multiple input/multiple output (MIMO) wireless network technology, called Bell Labs Layered Space-Time (BLAST). In initial lab testing, the chips lived up to theoretical predictions, receiving data in a 3G mobile network at a blazing 19.2 Mbps. BLAST uses multiple antennas at the terminal and base station to send and receive wireless signals at ultra-high speeds. The two chips have been tested successfully in four-antenna terminal configuration that also uses four transmit antennas at the base station. Lucent is also working to speed the commercial introduction of MIMO technology by making its family of Flexent OneBTS base stations MIMO-ready.

Lucent Technologies has also introduced a capacity-increasing chip that will be integrated into its new flagship CDMA2000 base station, the Flexent Modular Cell 4.0, and future products in the Flexent OneBTS family of base stations. The "ASIC" incorporates intelligent antenna capabilities that enable these base stations to support substantially greater volumes of voice and data traffic. According to Lucent, the ASIC, which supports CDMA2000, can deliver an additional two-fold increase in capacity by utilizing the intelligent antenna feature. It also can boost data capacity by more than 100 percent.

HP and Nokia have announced the availability of integrated machine-to-machine (M2M) connectivity solutions that link Nokia wireless technology with HP hardware and software to access and manage remote assets. Automatic meter reading, security, elevator control, fleet management and traffic control systems are among the applications of M2M connectivity.

Cable & Wireless Panama has announced the commercial launch of the world's first GSM/GPRS 850 MHz network. Ericsson is the sole supplier of equipment and services for the deployment of this network, which uses existing spectrum to provide operators a smooth transfer from TDMA to GSM/GPRS technology.

Philips has conducted a successful commercial network field trial of single antenna interference cancellation (SAIC) chips for GSM/GPRS mobile phones using Cingular Wireless network. This new semiconductor technology is said to improve voice quality and increase the number of calls supported on the network for greater all-around efficiency. The technology enables mobile handsets to remove interference from undesired signals while efficiently focusing on the signals from the most appropriate base station. According to a Cingular representative, the trial showed approximately a 20% increase in voice capacity and GPRS throughput.

IFONE has launched a GSM cellular network that is NSA Type I encrypted. The system, named the "Minuteman" can provide service to 300 users across an area of about 8 to 10 miles radius. Approximately, 50 users may operate secure with the General Dynamics NSA security devices.

The Mobile Wireless Internet Forum (MWIF) has announced that Telcordia and Toshiba have completed a first ever laboratory proof of concept demonstration of a mobile internet core network. The two companies demostrated four mobile internet functions: seamless mobility, secure mobile multimedia communications, customized mobile wireless services and plug and play mobile wireless network management. The test bed utilized an all IP wireless/wire-line network with 802.11b and CDMA2000 1xRTT wireless technologies.

IBM has developed a heart monitor that can send a warning message to a pre-determined cell phone when the user is in cardiac distress. The device uses short-range wireless technology such as Bluetooth to connect to a cell phone and transmit data in the form of a text message. Lucent is also developing an antenna and sensor that are added to a mobile phone and placed in front of the patient in order to monitor breathing and heart rate. The module uses the microwave signals produced by the phone to create a pattern as they bounce back from the chest, heart and lungs of the patient.

Nextel Communications is testing a new 6:1 vocoder technology that will enable it to double its voice capacity. The company plans to launch it commercially by Q3 of 2003. It has also demonstrated the first multi-area call using its Direct Connect walkie-talkie feature.

The University of California at Davis has announced that it has received a grant from the Defense Department to develop a new standard for optical cell phones that, according to the researchers, could make wireless communications speedier and more secure than existing optical fiber networks. The eventual aim is to create a cell phone that can connect to the fiber-optic backbone through optical, rather than electronic networks. The technology would be built on the CDMA standard.

Researchers from the University of Warwick have developed an optical antenna that uses a combination of precise curvatures on the lens and a multilayered filter. According to the researchers, this antenna is so precise that it can detect a signal on a single wavelength of light. The scientists also assert that the device is 100 times more efficient at gathering in a signal than any previous optical sensor of this kind, which could bring greater security to wireless networks for businesses.

Mobile Phones and Health Concerns

Japan's mobile phone operators, NTT DoCoMo, KDDI, J-Phone and TU-KA Cellular Tokyo have agreed to conduct a joint study on the possible biological effects of exposure to radio waves from mobile phone systems. According to the agreement, the four companies will analize and evaluate the results of experiments performed independently or jointly. The companies will initially study a preliminary research currently being carried out by DoCoMo, which will examine the effects of radio waves at both the cell and genetic level. The in vitro exposure system, or radio emission system, that will be used in the cell-culture experiments features an open design incorporating a horn antenna and dielectric lens. The equipment creates a wide and homogeneous electric field with a deviation of less than ±1.5dB over an area of 30 cm^2.

The Swedish Radiation Protection Authority has announced the results of the review of published studies on the relationship between the use of cellular phones and cancer risk by two internationally well-know US epidemiologists. According to the agency, no consistent evidence was observed for increased risk of brain cancer, meningioma, acoustic neurinoma, ocular melanoma, or salivary gland cancer, examined over a wide range of exposure measures, including type of mobile phone, duration of use, frequency of use, total cumulative hours of use, tumor location and laterality. The review also concludes that some of the published studies (including one from Lennart Hardell that demostrated an association between the use of cellular phone and cancer) are non-informative due to serious methodological limitations, a follow-up too short or numbers of cancers too small.

The Australian National Health and Medical Research Council is set to support a new $1.3million Centre of Research Excellence in Radiofrequency Electromagnetic Energy to study the possible health effects of electromagnetic energy emissions from mobile phones and mobile phone towers.

Scientists from the Hong Kong University of Science and Technology are working on a plastic-like material that is designed to prevent most of the radiation emitted from mobile phones from entering the human body. A local manufacturer, Wong's Electronics is partnering with the University to produce the material.

The President of COP-5 of the Basel Convention has launched an initiative to set up a pilot project on partnership with industry on the environmentally sound management of end-of-life mobile phones.

US Mobile Market

The Federal Communications Commission (FCC) allocated 90 megahertz of spectrum that can be used to provide advanced wireless services (AWS), including services commonly referred to as "Third Generation" or "IMT-2000." In a Second Report and Order ("Order") in ET Docket No. 00-258, the Commission allocated two contiguous 45 megahertz frequency bands located at 1710-1755 MHz and 2110-2155 MHz. Both bands are allocated for fixed and mobile wireless services. In a companion Notice of Proposed Rulemaking ("Notice") in WT Docket No. 02-353, the FCC also proposes licensing and service rules that permit these bands to be used for any service consistent with the bands' fixed and mobile allocations, including the provision of AWS.

The FCC has released a report on "Measured Emissions Data For Use In Evaluating The Ultra-Wideband (UWB) Emissions Limits in the Frequency Bands Used By The Global Positioning System". Previously, the Commission stated that it was concerned that the standards for UWB devices may be overprotective and may constrain the development of UWB technology. The Commission also established extremely conservative emissions limits to protect the Global Positioning Systems (GPS) against harmful interference. Since then, the FCC Laboratory undertook a study to measure the levels of ambient radio noise that exist in the GPS frequency bands at a variety of indoor and outdoor locations. The results of these tests show that the GPS frequency bands generally have very low levels of ambient radio noise in outdoor environments. In contrast, the GPS bands in indoor environments have levels of ambient radio noise well above the UWB emissions limits. The Commission's emissions limits were based on protection of GPS indoor operations. The FCC Laboratory also measured the radio frequency emissions from a number of radio frequency devices, including personal computers, hairdryers and electric drills. The study is available for public inspection and copying.

The FCC's Office of Plans and Policy (OPP) has released OPP Working Paper No. 38, "A Proposal for a Rapid Transition to Market Allocation of Spectrum." The paper proposes a methodology for efficiently restructuring a large amount of encumbered spectrum. In particular, it proposes that the FCC reallocate spectrum to flexible use and organize large scale, two-sided auctions in which encumbered spectrum, voluntarily offered by incumbents, would be auctioned together with presently unassigned spectrum. By making highly complementary spectrum available in a single auction, the reallocated bands could be quickly and efficiently restructured. The paper provides several specific examples of bands in the 300 to 3000 MHz range where this approach might be usefully be used. Applying this proposal to all the bands identified would provide a specific market mechanism for rapidly restructuring an additional 438 MHz in the 300 to 3000 MHz range so that it is in highest valued use. The full text of the paper is available at www.fcc.gov/opp.

The FCC's Spectrum Policy Task Force has presented recommendations to modernize the rules that guide how the nation's spectrum is managed and utilized and to evolve from a traditional government "command and control" model to a more flexible, consumer-oriented approach. The

Task Force's Report will provide a starting point for a long term review of spectrum policy approaches that could be implemented by the Commission. The text of the Report and other Task Force documents may be downloaded from the Task Force's web site at http://www.fcc.gov/sptf/

The FCC has issued a Notice of Proposed Rulemaking seeking comment on proposed licensing and service rules for the 5.9 GHz Band (5.850-5.925 GHz band) for Dedicated Short-Range Communications (DSRC) in the Intelligent Transportation Systems Radio Service. DSRC systems are being designed to provide a short-range, wireless link to transfer information between vehicles traveling at high speeds and roadside units, other vehicles, or portable roadside units. In this regard, DSRC will be essential to many ITS applications that are expected to improve traveler safety, decrease traffic congestion, reduce air pollution, and conserve vital fossil fuels.

The FCC has initiated a Notice of Inquiry to obtain comments from the public on the possibility of permitting unlicensed devices to operate in additional frequency bands. Specifically, they seek comments on the feasibility of allowing unlicensed devices to operate in TV broadcast spectrum at locations and times when spectrum is not being used, and on the technical requirements that would be necessary to ensure that such devices do not cause interference to authorized services operating within the TV broadcast bands. The FCC is also seeking comments on the feasibility of permitting unlicensed devices to operate in other bands, such as the 3650-3700 MHz band at power levels significantly higher than the maximum permitted for unlicensed devices in other frequency bands, with only the minimal technical requirements necessary to avoid interference to licensed and incumbent services.

The FCC has initiated a reevaluation of the scope of communications services that should provide access to emergency services. Most CMRS licensees are providing basic and enhanced 911 service pursuant to Commission rules. In its Further Notice, the FCC examines and seeks comment on the need to require compliance with its basic and enhanced 911 (E911) rules, or similar requirements, by various other mobile wireless and certain wireline voice services. The FCC considers whether existing services such as telematics or voice service provided by multi-line systems should be required to provide access to 911 service. The FCC is also considering whether some new services should be subject to any E911 requirements.

The FCC has issued a Notice of Inquiry ("NOI") seeking comment on the effectiveness of its current regulatory tools in facilitating the delivery of spectrum-based services to rural areas. Specifically, they ask whether and how the Commission could modify its policies to promote the further development and deployment of such services to rural areas.

The Office of the Secretary of Defense (OSD) has issued its Pentagon Area Common IT Wireless Security Policy, covering the use of wireless technologies as well as surrounding Defense Department offices. The policy prohibits wireless connections to classified networks or computers. The Californian Department of Transportation (Caltrans) is using a system of wireless links to transmit security data on seven bridges and three tunnels in the San Francisco Bay Area. The wireless links are tied-in to video cameras that will use video-over-IP technology to transmit data. The system uses both licenses and unlicensed spectrum, with most links using the unlicensed 5GHz band. Nextel said it won a US General Services Administration (GSA) contract to provide nationwide Enhanced Specialized Mobile Radio (ESMR) services to all federal agencies, as well as state and local agencies. T-Mobile has won a contract to provide network services to the US Army. The deal includes General Dynamics Corp supplying 10,000 secure mobile phones which will be used to access T-Mobile's GSM network. AT&T is planning to shut down its eight-year-old CDPD network by 2004.

The CTIA has released its semi-annual study of the state of the US wireless industry. Some of the findings of the study are: overall wireless subscribership increased to 134.5 million by June 2002, from 118.4 million one year earlier; US carriers earned services revenues of $36.7 billion in the first 6 months of 2002, up from $30.9 billion for the same period of 2001; total billable minutes of use for the first half of 2002 were nearly 300 billion, up 48% from the same period of 2001. A survey by Telephia claims the US wireless market has gone over 50% penetration. A survey of Solomon-Wolff Associates has found that 13% of US consumers are making all of their local telephone calls using wireless service. IDC is predicting that more than 23 million wireline access lines will have been displaced by wireless in the 12 years from 1995 to 2006.

Spectrum Licenses

ART, France's telecoms regulator, has awarded Bouygues Telecom the country's third UMTS license. The French company was the only applicant for this license. A fourth license is still available. According to Russia's Vimpelcom, the company has been approved to receive a GSM1800 license for Russia's Northwest license area, which has a total population of approximately 13.7 million. The company expects now to receive an official license shortly. Telenor Mobile and Tele2 have entered into 5-year agreements giving the companies Mobile Virtual Network Operation (MVNO) access to each other's GSM and future UMTS networks in Norway and Sweden. Norway is set to auction the fourth UMTS license that it took back from the former holder when it went out of business. The government has not changed the schedule for providing coverage.

Verizon Wireless has signed an agreement with Northcoast Communications LLC to purchase 50 personal communications services licenses and related network assets covering more than 47 million potential customers for approximately $750 million in cash. The licenses cover large portions of the East Coast and Midwest. The licenses include 10MHz in each of the 50 US markets, in the D, E and F blocks of the 1900MHz frequency band. AT&T Wireless and Cingular have announced plans to swap some of their licenses in a non-cash deal. The deal will provide AT&T Wireless licenses in Alabama, Idaho, Oklahoma and Mississippi and will allow the company to acquire Cingular's operations on the Hawaiian island of Kauai. In return, Cingular will receive licenses in Alabama, Georgia, Kentucky, Mississippi and Texas.

A consortium comprising Alcatel, Monaco Telecom International, MCT Corp and the Aga Khan Fund for Economic Development (AKFED) claims to have been awarded Afghanistan's second GSM license. TSI holds the country's first GSM license and there is also a temporary network in Kabul operated by the UN for their needs. According to Millicom International, Paktel, MIC's second cellular operation in Pakistan, has been granted a modification to its license and has been awarded GSM900 spectrum.

Industry Forecasts and Surveys

A new study by In-Stat/MDR has found that the messaging market (which includes Multimedia Messaging Service, MMS, and Enhanced Messaging Service, EMS) will con-

tinue to outstrip the wireless internet market in terms of subscribers, through 2006, growing from an estimated 305 million at the end of 2001 to more than one billion by the end of 2006. According to the company, the wireless internet market will grow from 74 million subscribers at the end of 2001 to more than 320 million subscribers by the end of 2006. Another study by Juniper Research has found that MMS has the potential to generate revenues in excess of $8.3 billion by 2004, as long as the operators meet a certain number of challenges such as implementing cross-network MMS and roaming facilities. The study also concluded that much of the revenue for MMS ($5.6 billion) will be generated via content delivery and provisioning rather than pure peer-to-peer messaging.

According to a new report from Alexander Resources, mobile gaming will be the first service to generate significant revenue and branding opportunities for 2.5G and 3G wireless networks, services and handsets. A study from IDC points out that the number of total American unique wireless gamers will climb from nearly 7 million in 2002 to 71.2 million in 2007. On the other hand, a survey published by Analysys concluded that western European operators would see sales of mobile games swell more than 10-fold to 3 billion euros in 2005 from 245 million euros in 2002. Operators across Western Europe are now introducing arcade-type games that can be downloaded to mobile handsets. In Japan, where Java handsets where introduced in early 2001, some 43% of NTT DoCoMo's 35.2 million subscribers are now using downloaded Java services. A survey conducted by the Java games provider, IN-FUSIO, and Orange revealed that 20% of those questioned said that the games service offered directly influenced their purchase of a mobile phone. The survey, conducted amongst a sample of 600 existing Orange customers, said that 50% of mobile gamers play for an average 22 minutes in each session and 75% of mobile games players prefer to play at home. 78% of the players were under 25 and 92% under 34.

According to a new report by Forrester Research, only 10% of European mobile users will use a 3G mobile phone by 2007, which will delay 3G profits until 2014 at the earliest. The company calculated that even with operator's unrealistic penetration assumptions they will need to triple 3G user ARPU to break even in five years. The report also suggests that countries like Finland, France, Italy and Switzerland will hit break even earliest between 2010 and 2012.

According to new research from IDC, the worldwide handset market will rebound from its worst year ever and increase shipments 1.8% in 2002. The firm also expects shipments to increase from 391 million in 2002 to 606 million in 2006, which represents a compound annual growth rate of 9.5%. The Japan Electronics and Information Technology Industries Association (JEITA) has forecasted that 2003 worldwide handset demand will increase to 434.5 million units from an estimated 396.1 million units for 2002. JEITA also expects the Japanese market to rebound to 42 million units in 2003 from this year's estimated 41.2 million units. Nokia has also announced that it expects 10% or slightly more handset market growth in 2003, while anticipating a challenging industry environment in wireless infrastructure to continue. Nokia continues to believe the total market volume for handsets will reach 400 million units in 2002. The manufacturer expects growth in 2003 to be driven by a combination of subscriber growth and a stabilizing replacement cycle. The company projects that the mobile subscriber market will grow from more than 1.1 billion at the end of 2002 to approximately 1.5 billion in 2005, while the annual share of the replacement market will continue to grow from the current 50% level. For the full year 2002, Nokia expects the total wireless infrastructure market to be down approximately 20%. For 2003, Nokia anticipates that the total market in mobile infrastructure will be down approximately 10%.

According to a new report from Strategy Analytics, 26% of cellular handsers worldwide will be made by outsourced production in 2002; with the figure rising to 38% in 2007. The report also concludes that Flextronics, which is currently the world's 3rd largest handset manufacturer after Nokia and Motorola, will be the world's largest contract handset manufacturer in 2002, with an estimated 42% share in 2002.

Wireless LAN and Bluetooth

Qualcomm has announced the successful completion of what it claims is the world's first Bluetooth-to-WCDMA (UMTS) voice calls. The WCDMA voice calls were made under laboratory conditions using commercially available Bluetooth headsets interfacing with Qualcomm's MSM6200 Mobile Station Modem chip on a Subscriber Unit Reference Development System platform. Voice calls were both originated from and terminated at the Bluetooth headset. Bluetooth-to-GSM voice calls were also demonstrated using the same MSM6200 chipset and SURF platform.

Lucent has announced the successful seamless handoff of a wireless data call from a "WiFi" network to a UMTS network. During the trial users were able to initiate a secure Internet session on an 802.11 WLAN or a 3G UMTS network, and maintain it while moving from one network to the other. The successful testing incorporated a key standard established by IETF, Mobile IP, that enables seamless inter-technology handoffs between 802.11 and 3G technologies, which are essential to maintaining "always-on" high-speed mobile Internet connections. Lucent also has demonstrated seamless roaming capabilities between WiFi and 3G CDMA2000 wireless networks.

O2 Ireland has chosen Nokia to be sole supplier of its public WLAN system, which gives O2 Ireland's customers flexible wireless broadband access to Internet and corporate intranet services in public "Wi-Fi Zones(TM)", such as airports and hotels.Under the agreement, Nokia is providing its Operator Wireless LAN solution, while IBM Global Service is providing system integration services.

The Swedish Space Corporation (SSC) announced that they have transmitted information via a broadband wireless link over a distance of 310km. The link was made between a stratospheric balloon and a base station. Onboard the balloon was an antenna, supplied by Alvarion, connected to a high-power amplifier, a camera and a server. The information (such as environmental conditions and weather patterns) between the balloon and the BS was transmitted over the 2.4GHz spectrum. Researchers at the San Diego County High Performance Wireless Research and Education Network (HPWREN) have achieved a 72-mile Wi-Fi link to San Clemente Island off the coast of California. The link runs at the maximum one-watt power output allowed for 2.4GHz equipment and has two 40-inch grid antennas, on at each end of the link, to boost the signal. The link is used to allow scientist to collect data vital to better understand seismic activity along the southern California coastline.

The Wireless Fidelity Alliance has announced a new security specification based on an IEEE standards effort called Wi-Fi Protected Access (WPA) to replace the existing Wired Equivalent Privacy (WEP). The WPA standard uses

Temporal Key Integrity Protocol (TKIP), which generates new keys for every 10K of data transmitted over the network. This new standard is expected to first appear in products during 1Q of 2003.

United Parcel Service is beginning to deploy a tracking system that combines the Wi-Fi and Bluetooth wireless technologies. According to a UPS representative, 55,000 package handlers eventually will get Bluetooth bar code readers that are worn on the finger like a ring. The ring scans a package label and sends the information to a Wi-Fi radio attached to a handler's belt. The radio then sends the information to a central computer. UPS is testing the system in four hubs and it plans to install the gear inside 1,700 US package-sorting centers by 2004.

IPone, a WLAN solution provider, has announced that they have conducted WLAN roaming with commercial cellular networks for 2.5G and 3G. The trial used WLAN devices equipped with an IPone AirGate2000N 802.11 WLAN card and IPone's roaming client/server software. IPone's roaming solution follows Mobile IP and is not dependent on network and hardware.

According to the New York Times, the US Defense Department is warning that wireless networking technology could interfere with military radar systems. The Defense Department has suggested that Wi-Fi may jam as many as 10 types of radar system used by US military forces. Industry executives have insisted that military uses can coexist with the millions of smart wireless internet devices.

A new study from Gartner Dataquest said that worldwide WLAN shipments are on pace to grow 73% in 2002, while revenue will increase 26%. According to the study, the industry will continue the consistent growth in 2003 as worldwide WLAN shipments total 26.5 million units, up from 15.5 million units in 2002. In a different study, In-Stat/MDR projects that worldwide annual Wi-Fi node shipments will be 33 million in 2006, up from approximately 6 million nodes expected to ship out in 2002. Although the US is expected to remain the largest market for WLAN equipment, Asia Pacific region is quite notable for its growth.

The Bluetooth Special Interest Group (SIG) has announced that an independent study conducted by Zelos Group predicts that the use of Bluetooth wireless technology will result in cumulative incremental revenues of $12 billion by 2006. The bulk of these revenues will result from use of Bluetooth wireless technology to link cell phones with notebooks and PDAs to access data services including email. The study also predicts the automotive industry as a key medium-term driver for the adoption of Bluetooth. A different study conducted by ABI ("Automotive Wireless Networks: Examining the Proliferation of WLAN and PAN Technologies into the Automotive Platform") forecasts that nearly 20% of all new vehicles worldwide will contain embedded Bluetooth hardware by 2007. In the US, some Chrysler vehicles already use a Bluetooth hands-free car kit. Meanwhile in Europe, specific Saab and BMW models will also offer Bluetooth hands-free car kits.

Wireless, PMR and Public Safety

The TETRA World Congress 2002 took place in November at Nice Acropolis. Over 950 participants attended the event, which featured sessions on TETRA now, the economics of TETRA, IP, applications, next generation products and services, interoperability and the future challenges facing TETRA. During the event, Motorola launched MBTS, the industry's lightest dual-antenna eight channel TETRA base station, designed for Motorola's Dimetra IP system. On the other hand, Nokia presented a vehicle mounted TETRA radio offering versatile connectivity and advanced positioning with a direct interface to a GPS receiver.

Motorola announced the industry's first successful deployment of a TETRA-based radio communications system in Venezuela. The new system will provide advanced digital radio communications capabilities for police and security personnel in the State of Táchira. Meanwhile, Nokia announced it will provide its digital TETRA professional mobile radio system to Monagas State government in Venezuela. Nokia will also deliver a complete TETRA network using IP technology to Bulgarian National Service Border Police. The network is expected to be operational during first half of 2003. This new TETRA network will cover the border area between Bulgaria and Turkey providing advanced applications such as Automatic Vehicle Location solution for the border authorities in order to further enhance the force's security communications.Moreover, the Finnish manufacturer has signed a contract with Moratel, Morocco's sole TETRA licence holder, for a complete TETRA system using IP technology. According to the company, this will be the first digital professional mobile radio system in the country. Nokia is also providing a nationwide TETRA professional mobile radio system with end-to-end IP data functionality network to Tunisian TV broadcaster L'Office National de Télédiffusion (ONT), the country's sole TETRA licence holder.

Motorola was chosen to provide the radio communication system for the NATO Summit being held in Prague on November 21-22 2002. Motorola's TETRA network for the Summit was based on the existing network, which is owned by the City of Prague. The Prague system, supplied by Motorola, usually is used for traffic services, road maintenance teams and the Prague City Police. Motorola also announced the availability of secure, wireless, Virtual Private Network (VPN) functionality on its Dimetra IP TETRA system. VPN functionality allows multiple organisations to realize the benefits of a shared system, however each organisation will operate on its own closed network, meaning it cannot "see" outside of its network and other users cannot "see" in. The VPN functionality is available for both voice and data. The US manufacturer has also introduced Internet Protocol packet data services over its Compact TETRA system. Moreover, the capacity of the system has been increased to support up to 10,000 users and up to eight sites.

The international public safety mobile broadband standardization partnership, Project MESA, has approved three new documents: Project MESA Definitions, Symbols and Abbreviations; the Project MESA Statement of Requirement (SoR) Matrix; and the revised and updated SoR. The SoR, which has been defined by users themselves and is based on scenarios and analyses of real-life events, outlines advanced mobile broadband scenarios and definitions of the services to be supported by broadband public safety mobile telecommunications networks.

Ericsson Response and the Royal Institute of Technology (KTH) in Sweden have initiated a project aimed at improving the co-ordination between relief organisations through the sharing of technical resources and to reduce the costs of communication. The project is proposing a complete IP connectivity solution for relief organizations working in disaster areas. It provides a carrier class network solution for WLAN access, local traffic between and within the relief organizations. The solution also proposes connectivity to the outside world via a satellite connection.

Wireless Subscribers Figures

The International Telecommunication Union (ITU) has released its first Mobile/Internet index as part of a research report entitled 'Internet for a Mobile Generation'. The Index measures how each of more than 200 economies are performing in terms of mobile and Internet technologies and how likely they are to be able to take advantages of new developments in this field. The report noted that although the economies that score highest in the report, like Hong Kong (China), Denmark or Sweden are all high income, there are many low, lower-middle and upper-middle income economies doing much better than their relative GDP per capita would lead one to expect. Among the lower-middle income economies, the Philippines (33rd) is in the best position to be a rapid adopter of the mobile Internet, particularly due to a relatively open market structure. China (47th) is also well positioned relative to its modest GDP per capita. According to the ITU, there are a number of factors that will enable the rapid growth of the mobile Internet. First and foremost, the timely deployment of high-speed 3G networks will be a crucial catalyst for the generation of diversified multimedia services. Second, the availability and affordability of adequate Internet-enabled handsets will be a prerequisite for mass penetration. Finally, the development of unrestricted and non-proprietary mobile Internet content needs to be actively fostered. More information can be found in www.itu.int/mobileinternet

According to the Global Mobile Subscriber Database, there were 1.03 billion mobile subscribers at the end of June 2002, which represents an increase of 22% over the 846 million users worldwide a year earlier. According to the report, Eastern Europe was the fastest-growing market, with 62% annual growth to 59.78 million subscribers at the end of June. The region has also four of the world's six fastest-growing markets with more than 1 million subscribers: Russia, Ukraine, Bulgaria and Lithuania. In terms of sheers numbers, the strongest growth was observed in the Asia-Pacific region, with 379.94 million subscribers at the end of June of which 176.17 million were in China. Western Europe is the second largest market (290.35 million subcribers) followed by North America (144.71 million subcribers), Latin America (91.7 million subcribers), Eastern Europe (59.78 million subcribers), the Middle East (40.45 million subcribers) and Africa (27.63 million subcribers).

The CDMA Development Group (CDG) has reported that there were nearly 135 million CDMA subscribers and 24 million CDMA2000 users worldwide at the end of the third quarter of 2002. The CDMA subscriber base grew by 31% over the past 12 months, driven by new developments in Asia, Latin America and Europe and the success of CDMA2000 services. CDG also claims that, in North America, CDMA is the dominant wireless technology with more than 58 million subscribers. Latin America is one of the fastest growing regions for CDMA. The CDMA2000 subscriber base grew by more than 10 million during 3Q 2002. Nearly 18% of CDMA subscribers worldwide have access to 3G CDMA services today. In Korea, more than 40% of subscribers are using CDMA2000, twice as many as at the beginning of 2002.

According to the GSM Association, some 95% of world's countries have now adopted GSM mobile technology. According to the Association, there are now just eight major countries around the world that have not chosen GSM: Colombia, Djibouti, Ecuador, Eritrea, Haiti, Iraq, Uruguay and Zaire. According to figures released by the association 3G Americas, GSM proved to be the fastest growing wireless technology in Latin America during the twelve months ending in June 2002, and TDMA saw the largest absolute number of new additions in the region during the same period. From July 2001 to June 2002, GSM registered a 59% year-over-year growth rate, moving from 3.4 million to 5.4 million subscribers. During that same time, TDMA saw a rise of 14.5 million new Latin American customers, for an over 36% annual growth in the region. According to 3G Americas, beyond Latin America GSM continues to lead the global wireless marketplace contributing 82% of the growth in the mobile industry, or about 163 million new GSM customers of the total 201 million new wireless customers added over the last twelve months.

Forums and Industry Alliances

Lucent Technologies, Atos KPMG Consulting, Boston University, BP, Hewlett Packard, INSEAD, London Business School and Sun Microsystems have joined to form the 3G enterprise Alliance, a broad-based group focused on promoting the benefits that UMTS can offer to enterprise end-users. At a Forum held in October to discuss the benefits of integrating 3G services into the enterprise and corporate markets, members of the alliance agreed on key business benefits of mobile high speed data access including: increased productivity for the workforce; reduced operational expenditure; more effective management of the mobile workforce; and increased customer satisfaction. More information can be found in http://www.3gea.com

LG Electronics, NEC Networks, Nokia and Samsung Electronics have joined forces through the newly formed, Open Base Station Architecture Initiative (OBSAI). The OBSAI signals the commitment to create an open, competitive, mobile network element module industry. OBSAI will lead to modular radio base stations featuring open internal interfaces. Radio base stations developed using Open Base Station Architecture will be fully compatible with standard radio interfaces, such as WCDMA, GSM/EDGE and CDMA. The initiative will focus on the base station architecture and internal interfaces. More information can be found in www.obsai.org. Meanwhile, the Open Mobile Alliance (OMA) has announced it has set standards for applications such as Internet browsing, picture messaging, video downloads and email alerts.

Coding Technologies, Matsushita and NEC have jointly announced that they have introduced a new low-power decoder version for the upcoming MPEG-4 AAC-plus-SBR standard, which achieves CD-quality audio at low bitrates. MPEG-4 is being used in the video recording/playback of several Japanese video phones.

Wireless Data

Qualcomm and Eyematic, a visual communications software provider, have announced Eyematic's "Shout Messenger" animated messaging service, enabled by Qualcomm's Binary Runtime Environment for Wireless (BREW) platform. Shout Messenger, the first commercially available wireless animated messaging service in the United States, is available on Verizon Wireless' BREW-enabled Get It Now service.

Bouygues Telecom has announced the introduction of i-mode, the service developed by DoCoMo, to the French market beginning November 15, 2002. Base N.V. has also announced the introduction of the i-mode service in Belgium. Meanwhile, NTT DoCoMo announced the introduction of a new i-shot handset featuring the world's first 3D mobile phone screen. The handset incorporates a 3D color LCD and 3D editor function, enabling users to convert 2D still shots and downloaded content into 3D images.

The Ministry of Information and Communication (MIC) of South Korea has decided to adopt a single wireless internet access platform, known as WIPI (wireless internet platform for interoperability). WIPI has been developed by a group of Korean telecom professionals.

The European Telecommunications Standards Institute (ETSI) is holding a series of four seminars in various venues around Europe to help companies apply mobile technology to their businesses. These 'm-Commerce Discovery Events' are being organized by ETSI Project M-Commerce (EP M-Comm) and will cover both the financial and telecommunications aspects. More information on the different events can be found in http://www.etsi.org/frameset/home.htm?/pressroom/Previous/2002/MCOMM_Seminars.htm

The world's first MMS (Multimedia Messaging Service) interconnection was inaugurated in Finland between operators Sonera and Radiolinja, using equipment from vendors Nokia and Tecnomen.

According to a new Wireless Device Strategies report from Strategy Analytics, 10 million embedded-camera phones were sold worldwide in the first 9 months of 2002. Almost half the sales were in Q3. The firm expects 16 million camera phones to be sold worldwide in 2002. Meanwhile, Japan's J-Phone Vodafone has said that the number of subscribers to its video messaging services has passed the 1 million mark after just 9 months since the service was introduced in March 2002. On the other hand, NTT DoCoMo has announced that sales of i-shot handsets, allowing subscribers to transmit still images taken with compatible mobile phones having built-in digital cameras, have topped the 4 million mark. The service was launched in June 2002. The Japanese operator has also announced it will soon launch a new service that will allow i-mode users to interactively participate in live TV and radio programs.

Location Technologies

Nokia and Radiolinja, the Finnish mobile operator, have successfully demonstrated Service Area Identity (SAI) positioning technology as part of the Nokia mPosition solution. The field trials were carried out using Radiolinja's "pre commercial" WCDMA network and achieved good results in accurately determining a user's position within the range of a single network cell. The field trials were carried out in a combined urban and suburban area in Tampere, Finland. Most tests were carried out in a moving vehicle. Service Area Identity is an advanced position technology used in WCDMA networks to determine the physical location of a mobile subscriber, thus enabling location-relevant services which are one of the key elements in the Mobile Internet. Deployment of SAI positioning can be made with minimum additional network investment because the GSM and WCDMA network architectures can use the same positioning calculation and Gateway Mobile Location servers. There is virtually no cost burden for terminals either, since SAI does not require any support from terminals.

Cambridge Positioning Systems (CPS) has filed with the Federal Communications Commission (FCC) details of new E-OTD (Enhanced Observed Time Difference) test results that show substantially improved location accuracy. In field trials, CPS delivered accuracy performance of 46 meters (67% of the time) and 92 meters (95% of the time). These achievements are well within the FCC's October 2003 requirement of 50 meters (for 67% of the time) and 150 meters (for 95% of the time). The trial involved a citywide technology deployment including a range of urban, suburban and rural environments.

Cingular Wireless has announced it is changing the technology that it will use to meet the FCC's requirement of location accuracy of callers dialing 911 from mobile phones. The operator, that initially planned to use E-OTD, will use instead a technology called U-TDOA (Uplink Time Difference of Arrival). The US company claims to be uncertain of whether E-OTD could meet the FCC's accuracy requirements.

Other News

The sixth regional telecommunications Exhibition and Forum for the Asia-Pacific, was held from the 2 to 7 December at the Hong Kong Convention and Exhibition Centre (HKCEC), Hong Kong SAR, China. ITU Telecom ASIA 2002 combined policy initiatives and discussions with a trade showcase for information and communication technologies. For the first time at an Asia regional Telecom, ITU hosted a Youth FORUM. 76 young high achievers from 40 countries across Asia participated in four days of interactive panel discussions with industry leaders on topics of special interest to youth. ITU Telecom ASIA 2002 also incorporated a Telecom Development Symposium, a fellowship programme which brought delegates from the region's least developed and lowest income countries to Hong Kong to discuss development plans and address emerging issues of importance to their countries or region. A Global Symposium for Regulator was also held immediately after the event. In addition, the Asia-Pacific Telecommunication Indicators 2002 was also launched during the event. According to the report, in 2001, the region emerged as the world's largest telecommunication market. Mobile communications contributed to raising total teledensity dramatically in many developing countries. More information on the event can be found at www.itu.int/newsroom/

The CTIA WIRELESS I.T. & INTERNET 2002 event took place in Las Vegas from the 16th to the 18th of October. Special interest seminars included: Wireless Data University, the Wireless Developer Forum, the CDMA2000 Wireless Internet Optimization course, the Mobile Entertainment summit, the WLAN Applications & Demonstration Conference and the Oppenheimer Business Valuation & Sale of Business Seminar. The event also included The Federal Wireless Users' Forum (FWUF), the Global Wireless Education Consortium (GWEC) and the Mobile Healthcare conferences. The event also featured a new special interest pavilion "Safety & Security Pavilion: On the Road and in the Homeland" that showcased innovative wireless technologies aimed at bolstering Homeland Security.

The Swiss national rail company has awarded a contract to Siemens Mobile to build its mobile railway network, based on the GSM-R standard.

Alcatel has announced that it has been selected by Globalcom Data Services (GDS) to install a nationwide LMDS (Local Multipoint Distribution Services) broadband wireless network in Lebanon. The 26GHz-network rollout already covers Beirut and its suburbs and will be extended to Tripoli and the Jounieh regions in a near future. The French manufacturer has also announced it has signed an agreement with US Cellular to deploy microwave wireless transport equipment in order to expand network capacity and capability.

Mobile phone maker Sendo has announced it will license Nokia's Series 60 platform for smartphones (running on the Symbian operating system), breaking from the smartphone OS developed by Microsoft. Eforce, Culturecom and Mobile Telecom Network have announced the introduction of Chinese 2000 Mobile Linux, the mobile industry's first Chinese language Linux operating system.

Automotive Electronics

Bill Fleming, Senior Editor

Electrically Powered Supercharger

European automakers are looking for ways to improve fuel efficiency to meet their upcoming 2008 goal of 140 grams of CO_2/km (the equivalent of 41 mpg). In an effort to meet this goal, Visteon is developing an electrically powered supercharger targeted to improve the performance of small engines [1]. The system utilizes a compressor powered by a brushless electric motor. The compressor achieves 50,000 rpm operation within 330 ms after the driver's accelerator pedal depression requests acceleration.

A 1.2L gasoline engine equipped with this supercharger performs nearly as well as a 1.8L without the supercharger, yet fuel economy is 27% better. It was noted that, "in everyday driving, ninety percent of the time, you typically only use 30% of the torque available in your engine. You pay a large penalty in fuel economy to carry around extra power that you barely use." Use of a supercharger on a smaller engine is more fuel-efficient.

42-V Systems Regaining Favor

Assessments of 42-V technology voiced last fall at the SAE Future Car Conference in Costa Mesa, CA, have changed 180-degrees from those of two years ago. Beyond fuel economy and emissions reduction, 42-V architectures are increasingly seen as a necessity for new vehicle dynamics, safety, comfort and convenience features coming in the next 5 to 20 years [2].

For example, a *Design News* survey of automotive engineering readers identified three features achieved through 42-V architectures that were thought to be important, namely: (a) active suspension, (b) windshield heating, and (c) electromechanical valve actuation [3]. However, there are problems that remain to be solved — for example, 42-V batteries don't currently have the same long-life characteristics as their 12-V counterparts. Nonetheless, when the economy turns, vehicle power requirements will go up, and conversion to 42-V will become necessary. Simply increasing the investment in 12-V technology is merely a "stopgap measure, and continued postponement will ultimately result in a steeper and more expensive 42-V uptake curve."

Safety Still Sells, But Telematics May Not

A recent Insurance Research Council (IRC) survey of U.S. households found that 9 out of 10 recent car purchasers rated safety as an important factor in their decision to purchase or lease a new vehicle. More than half of recent car purchasers looked for information about the safety features of prospective vehicles, such as air bags or anti-lock brakes. Nearly one in five respondents sought crash-test results [4]. The study also finds that the public is well informed about recent vehicle design improvements such as side air bags and the purpose and proper use of safety features such as head restraints. Most respondents (85 percent) were aware that automakers had begun to equip some vehicles with side air bags, and 6 in 10 respondents stated that the availability of side air bags would be an important consideration in the selection of their next vehicle.

According to a second study, "50 percent of those in the market for a new car said they will pay more for vehicles that have safety devices installed. Thirty-seven percent would pay more for hands-free cell phones, and 19 percent were willing to pay more for personalized traffic alerts." When in-car telematics technology was considered, demand diminished — only 11 percent of active Web users said they would pay extra for voice-activated Internet access, and just 8 percent would pay for Web display for passengers [5]. The authors subtitled their report, "Millionaires: The Last Hope For Telematics."

In still another survey, in the *Design News'* survey of automotive engineers; technologies were rated in terms of their ability to make driving safer. The top five safety-related technologies were [3]:

1. Crash resistant vehicle structures, cited in 54 % of the surveys
2. Antilock brakes, 46 %
3. Computer interlocks to prevent drunken driving, 33 %
4. Collision avoidance systems, 33 %
5. Controlled deployment (advanced) airbags, 32 %

The *Design News'* survey of engineers saw no safety improvement associated, however, with: voice-activated controls, navigation systems, and/or adaptive cruise control.

Accessory Fingerprint-Recognition Memory Presets

The new 2003 Audi A8 includes a capacitive fingerprint sensor about the size of a postage stamp mounted on the IP center console. The sensor has 20-dots/mm (513 dpi) resolution, together with image processing that detects 24 fingerprint characteristics. Up to four different driver fingerprint identifications are recognized by the system [6]. Drivers can program individual preset preferences for: climate control, radio, seat, steering column, mirrors, and personal address books. Powertrain and chassis settings will also be programmable in future models. With the simple check of a fingerprint, the vehicle takes on the programmed settings of any of four drivers.

Bluetooth and Wi-Fi Slated for Automotive Production

Here we go again. It's now forecast that, "the use of Bluetooth and Wi-Fi[‡] wireless technologies will dramatically alter the face of the automotive environment in and out of the vehicle. Wi-Fi's main driving force stems from the FCC's allocation of the 5.850-to-5.925-GHz frequency band for dedicated short-range communications. The DaimlerChrysler/Johnson Controls/IBM/Gentex/Intel/ATT-Wireless, "U-Connect," Bluetooth hands-free option will mark Bluetooth's U.S. introduction into 2003 model-year Chryslers, Dodges, and Jeeps [7]. Similarly, BMW/Visteon are the first in Europe to install wireless Bluetooth in BMW 3 series, 5 series and X5 2003 models [8].

Bluetooth allows drivers to use cell phones, not necessarily handheld (phones can be left in the driver's pocket or briefcase), to communicate with the "head unit" in the vehicle IP which stores and processes voice recognition commands. Issues remain to be resolved. It hasn't yet been proven that out-of-bandwidth communication from Bluetooth devices and satellite radios wouldn't interfere with each other. Another issue is security because Bluetooth broadcast signals could potentially be intercepted by neighboring vehicles [9]. However, Infineon has announced that it's moving to meet this need, and is planning to introduce security encryption features in its wireless modem chips for use in Bluetooth applications [9A].

Digitally Enhanced Analog Radio Competes with Satellite Radio

As satellite radio services struggle for survival and terrestrial digital radio broadcasting suffers more dead air in the U.S., Motorola is gambling on old-fashioned analog AM/FM radio. Motorola has developed what they call "Symphony"-based digital signal processing of analog AM/FM radio channels. Their software utilizes 24-bit, DSP-baseband/audio, with 1,500 Mips of processing power [10]. "Symphony" signal processing offers consumers less static, fading, pops, and hisses; while allowing them to receive more AM/FM radio channels. And the improvement in sound quality between analog radio and Symphony-based digitally processed radio is comparable to the difference between the sound quality of cassettes and CDs.

Citing the existence of 4,400 AM/FM radio stations worldwide, Motorola made a conscious decision to "go where the money is," and they noted that the market is already heading for software-based radio architectures such as Symphony. New architecture radios, like Symphony, enter the market independently of station conversions, and can be sold in areas where there are no digital stations. Moreover, "there's no subscription fee for customers, there's no weird technology, and no funny antenna required [10]."

Paul Hansen reports [11] that, although the two U.S.–licensed satellite radio providers, XM Satellite Radio and Sirius Satellite Radio, are both struggling financially, Sirius' financial predicament today is more extreme[†]. The short-term success of satellite radio depends on consumer acceptance, whereas the long-term success rests on the automakers willingness to factory-install satellite radio.

Personal Robots

Honda first focused on biped robot walking technology in 1986. In 2000 announced the Asimo as a demonstration vehicle for the company's robotics activities. Both Honda and Sony are clearly at the forefront of robotics technology, but their strategies differ. Sony concentrates on entertainment robots, whereas Honda is seeking to build general-purpose robots that can act as companions to humans [12]. Humanoid robots are only expected to capture 10-to-15 percent of the market. Instead, there will be diverse shapes — wheel-based, snake-like, six-legged, etc. Just as in biology, there will be diversity in robots.

One of the next big challenges is to have robots run smoothly on irregular terrain. Today's motors and actuators don't stand the load of running. "Japan is expected to be the first society where robots and humans live together. In this sense, Japan will function as a test bed, and it's Japan's mission to tell the world what happens when robots encounter humans [13]." Sony is planning to introduce a commercial robot sometime within the next year. Its price will be comparable to the cost of high-end limousines.

Very Personal Computing

Speech-recognition pioneer Ray Kurzweil gave the keynote speech at Sensors Expo in Boston last fall. Ray predicted that, "by 2030, nanosensors could be injected into the human bloodstream; implanted microchips could amplify or supplant some brain functions; and individuals could share memories and inner experiences by 'beaming' them electronically to others [14]." Even now, manufacturers are experimenting with wearable computers using rf sensors embedded in clothing. For example, M.I.T.'s wearable computers enable businessmen to exchange business cards simply by shaking hands. By 2030, 'nanobots' might possibly be implanted simply by swallowing them like pills. Such human-computer pairings may increase life expectancy. But there may be a downside. Some self-replicating nanotechnogies may someday be considered as a form of cancer.

Saturn Has a Continuously Variable Transmission

The 2002 Saturn Vue features a continuously Variable Transmission, called the VTi transmission. According to test drivers, there is a total absence of shift feel, even during vehicle acceleration [15]. A flexible steel-link belt is compressed and driven between two variable-diameter pulleys. Pulley diameters are varied by hydraulic pressure, changing their diameters relative to the belt, thereby continuously changing the transmission gear ratio. GM states that the VTi has 45% fewer parts than conventional four-speed automatic transmissions, together with the fuel efficiency of a manual transmission.

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[‡] Wi-Fi is short for Wireless Fidelity, and is another name for the IEEE 802.11b Standard wireless local area networks. Products certified as Wi-Fi are interoperable with each other, even if they are from different manufacturers.

[†] According to Paul Hansen [11], both satellite radio providers have a way to go before they become profitable. XM Satellite had 200,000 subscribers as of September 30, 2002; and it will ultimately require 4 million subscribers to breakeven. Sirius had 6,500 subscribers as of August 11, 2002; and it will ultimately require 3 million subscribers to breakeven.

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Standards

Dennis Bodson, Senior Editor

IEEE -SA Standards Board Approves New VTS Standard

The IEEE Standards Board at its September 2002 meeting approved a new VTS standard in the Rail Transit area. It is 1570 (VT/RT) Standard for the Interface Between the Rail Subsystem and the Highway Subsystem at a Highway Rail Intersection.

World Standards Day

World Standards Day (WSD) was celebrated on 16 October 2002 in Washington, DC. The WSD's goal is to raise awareness of the importance of global standardization to the world economy and to promote its role in helping meet the needs of business, industry, government, and consumers worldwide.

ISO's U.S. representative, the American National Standards Institute (ANSI), is one of the founding organizations of World Standards Day. Today, World Standards Day is sponsored annually by ISO; the International Electrotechnical Commission (IEC), which develops international standards for the electrical and electronics industries; and the International Telecommunication Union (ITU), an international organization responsible for the coordination, development, regulation, and standardization of telecommunications standards.

The IEEE Standards Association and the IEEE Vehicular Technology Society were represented at this event.

IEEE Standards Board Announces the Geoport Project

The IEEE Standards Association has been developing a global portal network (aka the "geoport" project) to better serve its constituencies worldwide. The first portal was successfully launched in July focusing on constituents in Asia.

Keeping to schedule, the IEEE-SA announced on 20 November the launch of StandardsAmericas? (www.standardsamericas.net). This will launch with communities for Canada and Brazil; the United States and Mexico will debut in early 1Q-2003. To date, the range of individuals submitting Community Spotlight profiles has been gratifying: IEEE-SA members from Argentina, Brazil, Canada, Chile, Mexico, and the United States are in queue to make their appearance on Standards Americas?.

In parallel with the Americas launch, StandardsEurope? is also being prepared. The development work for StandardsEurope? is complete, with its launch scheduled for the first quarter of 2003. IEEE-SA members from Germany, Italy, Poland, and the United Kingdom have submitted Community Spotlight profiles in anticipation of the launch. Available for preview at www.standardseurope.net, StandardsEurope? will make its 1st public debut in early December, for preview at the European Internet tradeshow, London Online.

Awareness of StandardsAsia? continues to grow. Marketing collateral is being disseminated at IEEE GlobeComm-2002, held this November in Taipei, Taiwan. Additionally, StandardsAsia? now ranks as the #1 search result on Google when searching by "standards asia." Marketing collateral for StandardsAsia and StandardsAmericas is being disseminated at the tradeshow COMDEX-2002, held this November in Las Vegas.

IEEE VTS NEWS

Call for Nominations: VTS BoG Elections

Nominations are sought for VTS members to serve on the VTS Board of Governors for the three year term from 1 January 2004 until 31 December 2006. Further details can be obtained from Past President J.R. Cruz at the address on Page 2, to whom nominations should be submitted by the end of March. This will allow the Nominations Committee to consider them prior to the April Board meeting, where a slate for this year's election will be agreed.

VTC2003-Fall in Orlando

Last call for papers for VTC2003-Fall in Orlando. Due to many requests for an extension, the deadline for submission for VTC2003-Fall has been put back to 10 March 2003. Details are on http://www.vtc2003.org

VTC2002-Fall in Vancouver

Vancouver played host to a highly successful VTC last September. A report would normally appear in this issue, but even 48 pages has not proved sufficient and we have to hold this over until the May issue. If you can't wait that long, you can find the article on the VTS web site.

James R. Evans Avant Garde Award

This VTS award is presented to a member who is being recognized for his/her pioneering work, leadership and other contributions to VTS and its activities. The term, "Avant Garde" is described for one who creates, produces or applies new, original or experimental ideas, designs and techniques in the field or interest; in this case, Vehicular Technology.

The award is named for James R. Evans, one of the founders of the Vehicular Technology Society over 50 years ago. An attractive desk-top /mantel, engraved, acrylic piece is awarded with a stipend of $250. See photo.

If you know someone in VTS who is deserving of recognition for their pioneering work in Vehicular Technology, please send details of your name, address and telephone number, along with details of who you wish to nominate (who must be a VTS member), and why you think they should receive the award and their VTS contributions to:

Raymond C. Trott, P.E.
c/o Trott Communications Group, Inc.
1425 Greenway Drive, #350
Irving, TX 75038
or email: ray.trott@trottgroup.com. A form can be found on the VTS web site.

IEEE VTS Chapter News & Meetings

Gasper Messina, Senior Editor

New York VTS Engineer of the Year

Mr. Gene Sansone, NYC Transit Assistant Chief Mechanical Officer for Car Engineering and Technical Support, has been selected to be Engineer of the Year by the Institute of Electrical and Electronics Engineers (IEEE) New York Vehicular Technology Society (VTS) Chapter. Gene will receive the award at the IEEE Fellow Awards Dinner Dance, February 22, 2003.

Gene is responsible for the activities of engineering and maintenance support on the world's largest fleet of rapid transit passenger and work cars. In addition, he is very active in the IEEE and other professional societies, and is the author of The Evolution of New York City Subways. He is also an Adjunct Professor at Polytechnic University of New York and a NYC College of Technology Advisory Commission member.

Under Gene's leadership, NYCT has prepared technical specifications for over half the car fleet and introduced innovations for customer convenience, improved reliability, and increased safety. In the past ten years, his group has prepared specifications for the R110A and R110B New Technology Test Trains, the R142, R142A and R143, and the R160. With options, these account for over 3400 cars. The good news for riders has included: electronic information signs, ac propulsion, automatic train announcements, and communications based train control (CBTC.) The CBTC system will change the way business is done at NYCT, as it creates a train to wayside link that ties the Signal and Car Equipment Divisions, and shifts major car maintenance responsibility to the Central Electronics Maintenance Facility.

In addition to these accomplishments, Gene is a member of the IEEE Steering Committee for Rail Vehicle Interface Standards, founder and past chair of the New York Regional Railcar Consortium and a participant in several APTA and Transportation Research Board committees.

Ottawa

The Ottawa Chapter of VTS held two meetings in 2002.

On 25 March 2002, Mr. Clive Packer of Moblesat spoke on the last mile connectivity to the Last places on Earth. This meeting was held jointly with AESS & British Computer Society, Ottawa Branch. Another meeting, also joint with the AESS, was held on 18 November 2002, when Kim Lochhead, of the Geodetic Survey Division of Natural Resources Canada spoke on the Canadian Differential GPS Project.

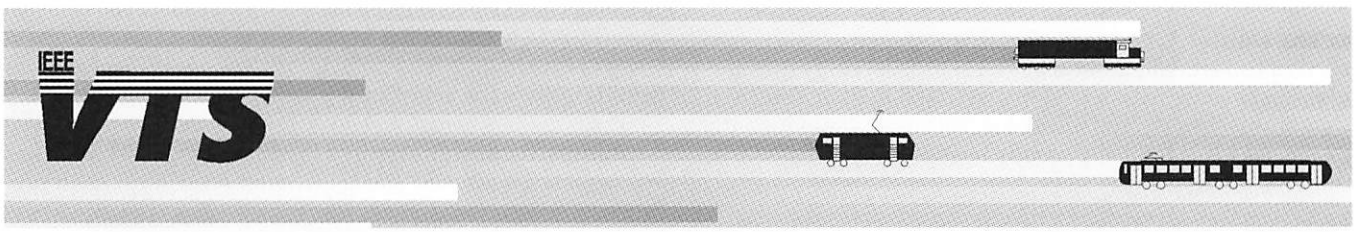
A further meeting on Inertial Navigation Systems will be held on 3 February 2003, before the annual dinner and talk, 'A History of Navigation'.

New York Section

The New York VTS section has elected new officers as follows in the photo to the right.

The New York VTS Chapter will be holding a technology sharing forum on 1 May 2003. Details on Page 23.

Left to right in the photo are Dr. Ramdane Benferhat, P.E., Treasurer; Don Willemann, P.E., Webmaster; Bradley Craig, P.E., Chairman; Chris Pacher, Secretary; David Weiss, Past Chairman and Vice Chair, Education. Dave Horn, P.E., Vice Chair Programs and Ken Vought, P.E., Vice Chairman Activities were not available for this photo.



VTS Awards

Ray Trott, Awards Chairman

IEEE and the Vehicular Technology Society (VTS) recognize those who contribute to and support the purposes of the Institute in an exceptionally worthy manner. The Institute has created and fostered a broad program of formal recognitions, scholarships and awards of all types. It encourages its Societies to recognize outstanding achievements and services for the benefit of the IEEE and the engineering profession, and for those accomplishments which enhance the quality of life for all people throughout the World.

This year, VTS presented several awards to those members who have contributed to and/or have supported the Society. These Awards and Fellowships were presented at the VTC's held in Birmingham, AL and Vancouver, BC, Canada.

There are several awards and fellowships that VTS considers in expressing its appreciation to members of the Society. Although all of these awards are considered, not all are awarded annually. These awards also have differing prizes: Plaques, Certificates and/or money.

At the Award Luncheons, the following awards were presented:

2001 Neal Shepherd Memorial Best Propagation Paper Award – This is to recognize the best paper relating to Propagation published in the *Transactions on Vehicular Technology*.

The award was presented to Mohsen Kavehrad, Homayoun Hashemi and M.R. Pakravan who authored, *"Indoor Wireless Infrared Channel Characterization by Measurements"*, July, 2001 VTS Transactions. The prize was a certificate and $166.66 for each of the authors.

2001 VTS Best Vehicular Electronics Paper Award – This is to recognize the best paper relating to Vehicular Electronics published in the *Transactions on Vehicular Technology*.

This was awarded to Sridhar Lakshmanan, Kesavarajan Kaliyaperumal and Karl Kluge for their paper, *"An Algorithm for Detecting Roads and Obstacles in Radar Images"*, January, 2001 VTS Transactions. The prize was a certificate and $166.66 for each of the authors.

2001 Jack Neubauer Memorial Best System Paper Award – This is to recognize the best paper relating to Systems Engineering published in the *Transactions on Vehicular Technology*. The Award is funded by VTS and Panasonic.

The award was presented to Jin Young Kim and Wan Choi for their paper, *"Forward-Link Capacity of a DS/CDMA System with Mixed Multirate Sources"*, May, 2001 VTS Transactions. The prize was a certificate and $250.00 for each of the authors.

2001 VTS Best Land Transportation Paper Award – This is to recognize the best paper relating to Land Transportation published in the *Transactions on Vehicular Technology*.

The award was presented to Osama T. Masoud and Nikolaos Papanikolopoulos for their paper, "A Novel Method for Tracking and Counting Pedestrians in Real-Time Using a Single Camera", September, 2001 VTS Transactions. The prize was a certificate and $250 for each author.

I would like to give special thanks to the following for their valuable time in the judging of the papers published in the VTS Transactions:

Joseph Ziomek, JFZ & Associates, for the Best Vehicular Electronics Paper;

Dr. Gordon Stuber, VTS Board Member & Professor, Georgia Tech, for the Neal Shepherd Best Propagation Paper;

George McClure, VTS Board Member, for the Jack Neubauer Best System Paper;

Dr. David Lovell, Professor, University of Maryland, for the Best Land Transportation Paper:

Outstanding Service Awards – These awards are given to members to recognize outstanding service to the Society. Prizes for these awards were plaques and stipends of $250 each.

- **Charles Backof** – For his outstanding service as Treasurer of VTS
- **James Irvine** – For his outstanding work as Editor of *VTS News*.
- **Thomas N. Rubenstein** – For his outstanding work as VTS Webmaster.

Chapter of the Year Award – This award is presented to recognize the outstanding Chapter of the Vehicular Technology Society. To be eligible, a Chapter must submit to IEEE Headquarters the meeting attendance report form, L-31. The award is a plaque.

The 2001 winner was the **New York VTS Chapter**.

The Daniel A. Noble Fellowship Award – This award is given to a student pursuing graduate-level study in Vehicular Technology with a preference to the field of Vehicular Communications. The awardee receives a plaque and $7,500 which is funded partially by Motorola, Inc. and partially by VTS.

The 2002 Winner was Ms. **Jing Jiang** who is pursuing a Ph.D. in Electrical Engineering, with emphasis in Wireless Communications Networks, at Virginia Tech, Blacksburg.

The VTS Convergence Fellowship Award – This award is given to a student pursuing graduate-level study in Vehicular Technology with a preference to the field of Transportation and Vehicle Components and Systems. The awardee receives a plaque and $12,000.

The 2002 Winner was **Phillip John Weicker** who is pursuing a Ph.D. in Electrical Engineering at McGill University, Montreal, Canada.

Stuart Meyer Memorial Award – This is an award to recognize those members of the Vehicular Technology Society who have both served their Society and also have contributed to the development of radio technology and science in an outstanding and exemplary manner. The prize is a plaque and a stipend of $2,500. The Award is funded by VTS and Ericsson.

This award was presented to **Evan B. Richards**, an active participant with the VTS Board of Governors over the past three decades and one of the Pioneers in Cellular System Implementation.

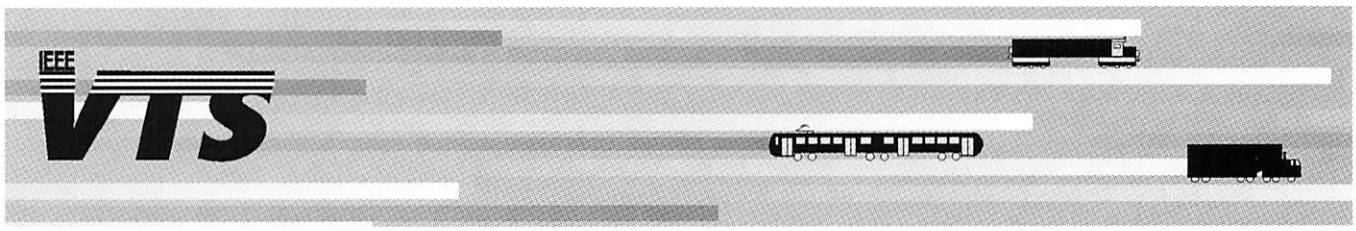
Mr. Richards was in Senior Management at Ameritech in Chicago and Belgium. He was instrumental in the development of the early Cellular AMPS beta system in the Chicago area (1983). From 1996 to 2000, he was Chief Operations Officer of Proximus Wireless (Belgium National Telephone). In addition, over the years, he has held top positions in the various companies associated with Ameritech.

James R. Evans Avant Garde Award – This award recognizes leadership and continuing contributions in pro-

Awards Chairman Ray Trott with Outstanding Service Award winners Charles Backof (top left), Tom Rubenstein (top right) and James Irvine (lower right), and giving a best paper award to Osama Masoud (top center left); (top center right) Vahra Hayat from Motorola (on the left) presents the Dan Noble Fellowship to Jing Jiang; (lower center) Mark Ehsani (left) presents the Convergence Fellowship to Phillip John Weicker; (lower left) Jin Young Kim and Wan Choi, winners of the 2001 Jack Neubauer Memorial Best System Paper Award.

moting new technology in the field of Vehicular Technology. The prize is a desk-top award and a stipend of $250.

This award was presented to Dr. **Theodore S. Rappaport** for his outstanding contributions to wireless communications in the past twenty years. A graduate of Virginia Tech, he has been a leader in the field. As the founding Director of the Mobile & Portable Radio Research Group (MPRG), he has propelled it to the top rank of wireless research laboratories in the World. Dr. Rappaport quickly rose through the ranks at Virginia Tech becoming a full Professor of Engineering in 1996. At the same time, he created two start-up companies, TSR Technologies and Wireless Valley Communications. He has received numerous professional awards and prizes over the years, including the Sarnoff Citation from The Radio Club of America, Inc. in 2000 and the 1999 Stephen O. Rice Prize Paper from the IEEE Communications Society. He is a Fellow of the IEEE and of The Radio Club of America, Inc. He was responsible for developing a large number of new courses at Virginia Tech. He graduated 5 PhD and 31 MS students. He has published or edited 18 books, refereed 55 journal papers and 84 conference papers. He has 4 granted patents and 19 pending patents. He has given many keynote speeches and invited talks throughout the World and has given many tutorials and workshops at some of the major wireless conferences.



History Column

The Avant Garde Award

Sam McConoughey, Past VTS President

The origins of the VTS date back to 1949, when the Institute of Radio Engineers (IRE) formed the Professional Group on Vehicular Communications. The First IRE – Professional Group on Vehicular Communications (PGVC) conference was held in Detroit, MI at the Book Cadillac Hotel. Approximately 35 persons attended to hear 8 technical presentations, and visit about a half-dozen exhibitors.

To commemorate this event, the Avant Garde award was created in 1980 to recognize the founders of the then IRE Professional Group on Vehicular Communications (PGVC) which later became the IEEE VTS. The first Avant Garde awards were made at our conference in Detroit that year. It was later agreed that the award be made permanent, to be awarded to those members of the Vehicular Technology Society who should be recognized for their work, leadership and other contributions to VTS and its activities.

The original award consisted of a pewter medal on which are depicted a hand holding shafts of lightning, a lamp, an ancient microscope and a diagram of electrons flowing around a nucleus. Attached to the medal was a blue and white ribbon with the words 'IEEE VTS AVANT-GARDE' in gold letters and a pin for attaching to one's suit or dress.

In 2001, the award was renamed the **James R. Evans Avant Garde Award**, being given to recognize leadership and continuing contributions in promoting new technology in the field of Vehicular Technology. The award itself was changed to a desk-top plaque and a stipend of $250.

Eighty-six VTS members have received the award since its creation. The full list of recipients is as follows:

Fumiyuki Adachi (May 2000)

Yoshihiko Akaiwa (October 1992)

Nick Alimpich (September 1980)

Lee M. Augustus (September 1980)

James G. Bender (February 1983)

Charles M. Boyd (June 1987)

A. B. "Buck" Buchanan (September 1981)

R. L. Casselberry (September 1980)

Arthur Collins (May 1986)

H. Hugh Davids (September 1981)

Raymond Donovan (September 1980)

John T. Eby (October 1986)

Mehrdad (Mark) Ehsani (May 2001)

R. J. Evans (September 1980)

Robert E. Fenton (May 1982)

Reed E. Fisher (October 1995)

William J. Fleming (May 1982)

Robert L. French (June 1990)

Gregory C. Gagarin (June 1987)

Eugene S. Goebel (September 1980)

Arthur Goldsmith (May 1986)

Joseph Gormley (May 1991)

Al Gross (February 1990)

Masaharu Hata (July 1995)

Charles A Higginbotham (May 1990)

Kenkichi Hirade (July 1995)

C. Lester Hogan (October 1982)

Basil P. Hooton (October 1986)

Laurence R. Howard (September 1980)

R. A. Isberg (June 1990)

Kazuo Izumi (April 1984)
Trevor Jones (October 1988)
F.L. Kahle (September 1980)
Wm. P. Keel (September 1980)
William E. Kelley (October 1992)
Kinoshita Kota (July 1995)
Michael Kotzin (July 1995)
Robert Lammons (September 1980)
William C.Y. Lee (May 1990)
Paul Ledwitz (July 1995)
Fred M. Link (September 1980)
Robert A. Mazzola (October 1982)
Oliver T. McCarter (May 1990)
Samuel R. McConoughey (September 1980)
John A. McCormick (September 1980)
John McFatridge (September 1981)
Robert W. McKnight (May 1990)
Stuart Meyer (September 1980)
Yoshifumi Miyano (April 1984)
Dearl O. Morrison (September 1981)
Yoshinori Nagata (October 1992)
Louis Nagy (October 1986)
John G. Nauman (October 1982)
Jack Neubauer (September 1980)
Ole K. Nilsson (October 1982)
Wilton J. Norris (September 1980)
Sven Olaf Ohrvik (May 1999)
Robert S. Oswald (October 1992)
Yasuo Otaki (April 1984)
Wesley W. Pendelton (May 1990)
Homer Penhollow (September 1980)
Theodore S. Rappaport (September 2002)
Alvin Reiner (May 1984)
Douglas O. Reudink (October 1995)
Gerry Rivard (October 1988)
Ronald G. Rule (May 1982)
Theodore Rykala (September 1980)
Chandos A. Rypinski (May 1990)
Lyle B. Saxton (May 1991)
Joseph J. Schmidt (October 1992)
Tom Selis (February 1983)
John F. Shaeffer (May 1985)
Neal Shepherd (September 1980)
Elmer Soldan (September 1980)
Russel M. Smith (October 1992)
Sadao Takaba (May 2000)
Robert E. Tall (1981)
David Talley (May 1984)
David B. Turner (February 1983)
Jan Uddenfeldt (May 1994)
Frank W. Walker (/1981)
James O. Weldon (May 1986)
H.E. Weppler (/1981)
William Whipkey (May 1985)
Walt Williams (September 1980)
Joseph F. Ziomek (October 1982)

VTC2003-Spring in Jeju, Korea

The VTC 2003-Spring Conference will take place on Jeju Island, Korea from 22 to 25 April 2003. The conference aims to present the current and innovative ideas to highly active mobile wireless society. Its objective is to provide the state-of-the-art wireless technology and a glimpse for the future of this exciting field both in academia and industries. Over 600 full technical papers and posters are to be presented, along with tutorials and business application/panel sessions. They will show original research results, innovative applications and developments, as well as experimental or field trial/test results in, but are not limited to, fields of wireless communication. Besides having intellectual exchange in sessions and tutorials, you will experience the most advanced 3G wireless services such as video transmissions through cdma2000 1xEV-DO/DV which are gaining popularity in Korea.

Jeju Island is located in the Pacific Ocean just off the south-western tip of the Korean peninsula. Known as a most beautiful island in Korea, Jeju Island is a volcanic island with a mountainous terrain, a dramatic rugged coastline, and spectacular watershed courses. International Convention Center Jeju is located at a most beautiful spot on the coast. Jeju Island has a mild oceanic climate, with average temperatures of 15°C, and various flowers will be in full bloom in April. Jeju Island is only a one hour flight south of Incheon International Airport and Seoul Airport.

Further details can be found on the conference homepage www.vtc2003spring.org The deadline for advanced registration, which gives a discount of between 15% and 25%, is **15 March 2003**.

Jeju can trace its communication history back a long way. Professor Moon Ho Lee discussed the Jeju Jong Nang code in the following article.

IEEE VTS

The History of Jeju Jong Nang Binary Code

Moon Ho Lee, Chonbuk National University

The island of Jeju, host to the VTC2003-Spring conference, has a long history in the communications field. Professor Moon Ho Lee of Chonbuk National University in Korea demonstrates the Jong Nang, an example of a binary code dating back over three quarters of a millennium.

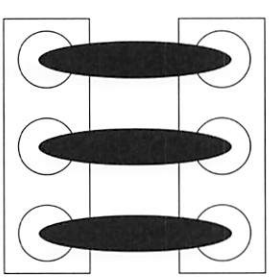
Introduction

Thirty years ago, in western society, F. G. Heath described the development of the binary code from Francis Bacon's "two-letter alphabet " which was conceived at the beginning of the seventeenth century, in "Origins of the Binary Code" [1]. Subsequently, Jacquardt's punch card operated loom (1805) and Boole's logical algebra (1854) led to the introduction of a binary telegraphic alphabet by Baudot (1875). Volker Aschoff, a Germany professor, reported the early history of the binary code in [2]. However, in oriental society, especially in Korea, concerned with 760 years old Jeju Island custom, Jeju *Jong Nang* Code is considered as one of the earliest Human Binary Coded Communication (HBCC) in the world with a definite "1" or "0" system.

Jong Nang, the wooden gate in Jeju Island dialect, had three wooden rafters placed on Jong-Ju-Mok (two large stones with three holes) to convey the family's whereabouts. A product of the wisdom of Jeju Island people in Korea, the *Jong Nang* was a unique custom of local culture. As there was no gate at the house in Jeju Island, timbers were used to prevent cattle or horses from entering and having the barley and millet that were spread out in the yard. Later, *Jong Nang* was developed into the means of informing visitors whether the residents were at home or not.

The *Jong Nang* used the binary system similar to digital communications and computers today. Three timbers were exactly like three binary digits. The *Jong Nang* system could convey eight different messages. One of three Jong-Nang placed between the Jong-Ju-Mok, or "100" indicated there was no one at home, but the family would soon return form a neighboring area. Two *Jong Nangs*, or "101" meant the family was visiting a neighboring town and it would be a while before they returned. All these *Jong Nangs*, or "111" announced the family was out of town for a long time, as shown in Figure 1. When none of the *Jong Nang* was placed, or "000", this meant the family was at home. This system derived from the life of the Jeju Island people [3,6–8].

(a). House with Jong Nang



(b). Jong Nang Code

Figure 1 Jeju Island Jong Nang

Although it is not exactly known when the *Jong Nang* first appeared, it is considered to be about 760 years ago, during the Koryo dynasty. It seems to have started after the construction of stone fences. Stone fences were first erected to show the boundary of land ownership. During King Kojong's era, government officials and judges were sent to Jeju Island. In A.D.1234, Ku Kim was appointed as a judge and he ordered residents to build stone fences along their boundaries.

The dispute over boundaries and the damage of agricultural products caused by grazing cattle and horses subsequently disappeared. The stone fences also acted as windbreaks. In addition, the collection of stones used to construct the fences contributed to easier cultivation and the quality of Island life. The Jong-Nang did not appear simultaneously with the erection of stone fences. To pasture cattle and horses in the Jung-sangan (=mountain) village on Jeju Island, the people built fence-like enclosures to prevent the animals from intruding onto farms. During the Chosun dynasty (A.D. 1392-1910), the practice became widely used across the Island.

The installation of 'Salchaegi' or 'Sombi' at the entrance became a starting point of the Jong-Nang. 'Salchaegi' or 'Sombi' originated as a field door set up vertically to pasture cattle and horses at the foot of Mt. Halla (1950m). It consisted of four to five thin logs or branches. At first, 'Sombi' was supposed to set up so that a horse could get in and eat crops located in the yard. When two *Jong Nang*s were used, large cattle or horses could not get in, but calves or ponies could. When one more *Jong Nang* was added, the calves and ponies could not get into the house at all.

Jong Nang Pattern	Jong Nang Communication	Jong Nang Digital code	Jong Nang Switching Channel/ Logic gate [8]
	Staying at home	000	0 0 0 → 1
	Visiting next door for a while	100	1 0 0 → 0
	Visiting a neighboring village	101	1 0 1 → 0
	Out of town for a long time	111	1 1 1 → 0

Table 1 *Jong Nang messages*

The digital logic analysis of *Jong Nang*

Definition 1: *Jong Nang* system is composed of 3 bits as shown Table 1 and each bit conveys different meanings. MSB (Most Significant Bit) as an existing bit indicates whether people are at home or not. When the existing bit is "0", it means someone is at home. Second bit is a spatial bit, so if this bit marks "0", it carries the information that the landlord stays near outside from his house. LSB (Least Significant Bit) is a temporal bit. "0" represents that no one is in house but returns in a short time. For each bit, "1" means the opposite case, as shown in Figure 2. This custom is similar fashion as space-time coding scheme.

Definition 2: The information priority of 3 bit *Jong Nang* system is MSB, Medium bit, and LSB in a sequence order, i.e. MSB>Medium>LSB.

Counter case 1) "001": MSB "0" shows someone is at home, second bit "0" means nobody at home for visiting near village and LSB "1" informs long time outgoing. Therefore, it is contrary to Definition 2, because the information priority does not follow the ordering.

Counter case 2) "110": MSB "1" indicates no body is at home, second bit "1" denotes long distance visiting and LSB "0" shows short time outgoing. But long distance visiting generally requires long time to come back home. This case also is contrary to Definition 2 for the same reason of counter case 1.

The above cases are not appropriate to the Definition 2, so they are not permitted in the Jong-Nang logic as shown in Table 2 (shaded entries).

Definition 3: The larger Hamming weight of *Jong Nang* message, the longer the outgoing time. For example, "111" represents that it takes longer outgoing time than "100" or "101". Table 1 shows the different *Jong Nang* messages.

In view of Jong Nang HBCC development, it's evident that they used to place the upper *Jong Nang* first, then lower, and middle one last. The introduction and Table 1 also explain its history, which is based on the oriental philosophy. But, today it is often used "001" (place the lower *Jong Nang* only) and "011" (place the middle and lower *Jong Nang*) patterns respective form earlier *Jong Nang* Philosophy.

The Fuzzy Concept Analysis of *Jong Nang*

The fuzzy concept was introduced by L. A. Zadeh for the first time in his "Fuzzy set" [5] paper in 1965. However, in Jeju Island, the fuzzy concept has been adopted to *Jong Nang* system about 760 years ago. They tried to represent the ambiguous concept (which usually contains various information hiding) through digital logic. We can perfectly certify this idea by NOR gate modeling.

In Table 1, *Jong Nang* of "100", "101" and "111" result in a NOR logic "0" output. However, the output "0" implies different intensity inputs such as *near*, *far* and *farther* distance.

Decimal	Binary	Comparison
0	000	**Staying at home**
1	001	**Not permitted**
2	010	**Not permitted**
3	011	**Not permitted**
4	100	**Visiting next door for a while**
5	101	**Visiting to neighboring village**
6	110	**Not permitted**
7	111	**Out of town**

***Table 2** The comparison of decimal and binary number in Jong Nang*

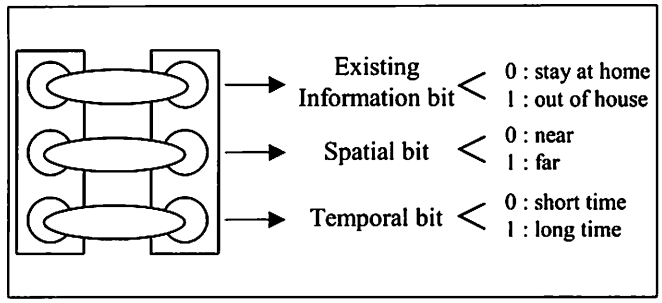


Figure 2 Jong Nang Information codes

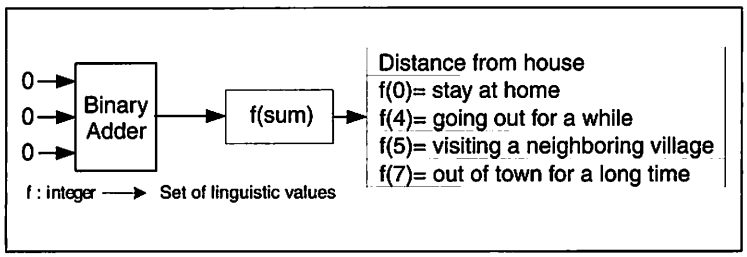


***Figure 3** The Jong Nang Fuzzy Logic*

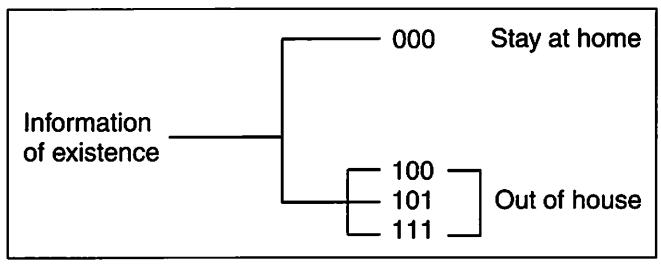


Figure 4 Jong Nang Tree

Figures 3 and 4 clearly show the mapping between spatio-temporal ambiguities and digital logic. Figure 5 is a life pattern transition diagram, which carries the information of family's existence.

On the whole, the Jong Nang HBCC symbolizes the basic oriental philosophy of heaven, earth and human. The Chinese character "正" (Jong) is composed of two characters: "一" meaning one or heaven, and "止" meaning that a man stands on the ground. "木" (Nang) which is slang for tree in Jeju Island.

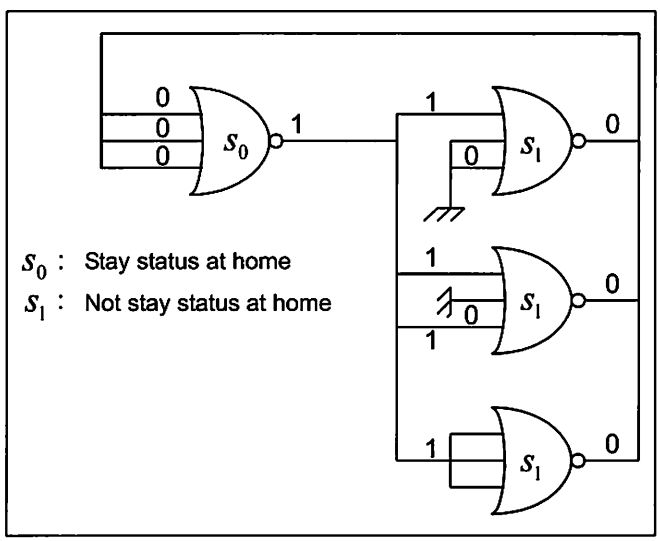


Figure 5 The Transition Diagram of Jong Nang

Conclusion

The history of binary code technology can be written from many different points of view. It can limit itself to the simple description of the historical succession from the invention to the further development of particular instruments, machines, or apparatus as has occurred in western thought. On the contrary, in eastern civilisation, the description is based on the natural status.

With these considerations, the ancient Korean Jong Nang HBCC was introduced. Now we are using this custom in Jeju Island. The relationship in the *Jong Nang* HBCC was explained in terms of digital logic, and also considered in terms of fuzzy logic to deliver the ambiguous information by using NOR gate modeling.

The *Jong Nang* HBCC was displayed at the Telecom. Pavilion of the Taejon Expo '93 (1993.8-1993.11) [3], where the history of world telecommunications were exhibited.

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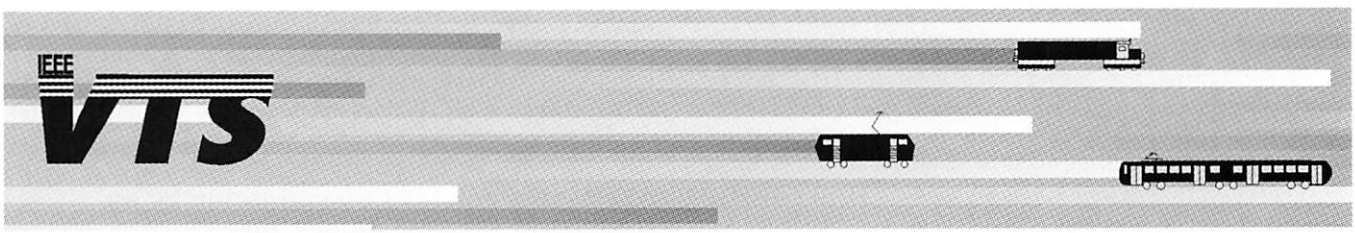
Professor Moon Ho Lee (moonho@chonbuk.ac.kr) is head of the Institute of Information and Communications, Chonbuk National University, Chonju 561-756. Korea.He received Ph. D. degree both in Electronic Engineering from the Chonnam National University, Korea in 1984 and Univ. of Tokyo ,Japan in 1990. From 1985 to 1986, he was in the Univ. of Minnesota, USA, as a Post Doc. From 1970-1980, he was a chief engineer at the NamYang Moonhwa Broadcasting company.



Joint Rail Conference

The 2003 Joint Rail Conference, sponsored by the Land Transportation Division of the VTS and the Rail Transportation Division of the ASME will take place in Chicago, IL from April 22nd to 24th 2003. In this issue we reproduce the abstracts of the 11 papers accepted from the IEEE in order to give you a flavour of the conference. There will also be papers at the conference from the ASME. A registration form appears on back cover.

Operational Safety Considerations in Designing a DC Traction Electrification System

Kinh D. Pham, P.E. Elcon Associates, Inc., Ralph S. Thomas, P.E. & **Walt E. Stinger**, P.E. LTK Engineering Services

This paper provides an overall integrated approach to operational safety issues when designing a dc traction electrification system. The traction electrification system (TES) includes an overhead contact system (OCS), traction power substations and underground cable system with associated substation protective devices and supervisory control and data acquisition interfaces. The paper looks at step and touch voltages present around the rails, at the station platforms and at the traction power substations.

Other topics discussed include substation grounding, rail-to-earth voltage tripping, protective relays, transfer trip, emergency shut-down trip stations(ETS), surge protection, OCS sectionalizing, feeder disconnect and bypass switches. Additionally, electromagnetic and induced voltage problems, and leakage stray current considerations in underground telecommunication cables and other metallic structures are considered.

To ensure safety, the Project must include follow-through with first article inspections of critical TES components, inspection and testing during commissioning and safety certification before the TES system is energized and put into operation.

Built-In Place Substation Buildings: An Attractive & Affordable Alternate To Packaged Units

Robert Hasting, AIA, Tri-Met, **Kinh D. Pham**, P.E., Elcon Associates, Inc. and **Ralph S. Thomas**, P.E., LTK Engineering

Traction Power Substations (TPS's) do not have to be unsightly and hidden in the most remote recesses of the project. The large painted metal boxes surrounded by cyclone fence which have become the familiar norm for many projects are being replaced by built-in-place buildings in Portland, Oregon, where Tri-Met and the community are concerned with aesthetics and have made the TPS an important and prominent design element. This paper discusses the general construction, costs, contract packaging, advantages/disadvantages and features of the Tri-Met built-in-place substation buildings and compare them with similar packaged units.

After using typical prefabricated substations on its first LRT project in the 1980s, Tri-Met has successfully constructed built-in-place substation buildings for the Westside, Hillsboro and Interstate MAX (IMAX) light rail

extensions. This approach has been well endorsed by the community, project architects, urban designers, systems engineers and Tri-Met operation & maintenance staff. The IMAX line's TPS building's design and materials were chosen to harmonize the scale of the substation in relation to its neighbors, and to be low in maintenance. The building's form is a response to local neighborhood, and property owner's request to fit into the scale of residential and urban streets. At many Westside and Hillsboro MAX locations, the TPS buildings are integrated with the station platforms. This consolidation of real estate reduces overall cost, and gives the urban designers and local artists enhanced opportunities for design and artwork. Landscaping is provided to blend into the neighborhood vernacular

Actual costs for the IMAX line's built-in-place substation buildings will be examined and compared with similar packaged units. Costs may actually be lower for built-in-place buildings in comparison with pre-fabricated buildings when all the costs such as real estate, conduit/ductbank, cable installations, etc., are properly considered. Other features such as maintenance advantages, project quality control, etc., will also be discussed in this paper.

A novel representation of 2x25kV high-speed railways power systems

Eduardo Pilo, Luis Rouco and **Antonio Fernández**, Universidad Pontificia Comillas, Madrid

As faster trains are being developed, electric power consumptions are dramatically increasing. Consequently, newer high-speed lines are usually fed with single-phase AC so that higher voltages can be used. In AC electrifications two different systems can be used: (i) simple and (ii) dual. In the simple system, a group of conductors is set directly to the feeding voltage. In the dual system, a higher voltage is used to transmit the energy and it is reduced to the rated voltage by autotransformers that are distributed along the line. Consequently, two different voltages are used to supply power to the rolling stock.

This paper presents a novel linear model to represent dual systems in a similar way to that used for simple systems, that has been developed for the optimization of high-speed railways power-supply systems design. The assumptions that have been made, which are related to voltage drops along the catenary and current distributions, are discussed in detail.

In this model, uncoupled equivalent circuits are proposed for positive and negative zones, including: (i) traction substations, (ii) catenary, and (iii) autotransformers. Depending on the required level of detail, some additional simplifications which can be applied are discussed.

A numerical example is used to compare: (i) the two-phases equivalent conductors model (used as a reference), (ii) the proposed model without any additional simplifications and (iii) the fully simplified model. Comparison criteria refer to (i) size of the corresponding networks (buses, branches, etc.), (ii) computational load required to solve the problem and (iii) estimation error introduced by the model.

An ATOS-PDA System for Train Operation Information Offered through Cellular Networks

Takuya Ishikawa, P.E., **Yoshiyuki Hirano, Hiroshi Yanagi** and **Katsuro Komazaki**, East Japan Railway

We have developed a new information system to provide our station staff with personal digital assistants (PDAs) with updated train operation information in the Tokyo metropolitan and suburban area. So far one of the most important problems to be solved in our company, JR East, Japan, is how early we could provide our passengers on the platform with precise train operation status in case of emergency. Offering the precise real-time information is necessary when a train incident occurs, since we are operating many trains with two-minute headway in some lines in the rush hours. Our station staff can now easily and promptly offer the precise train operation information to our passengers by the PDAs.

The contents of the PDAs include a train operation status monitor, a train position monitor, a train delay monitor, a train searching monitor and train incident information. These monitors are renewed every 30 seconds automatically.

The train operation information is originated from an autonomous decentralized transport operating control system (ATOS) developed by our company. ATOS is the largest decentralized system for ultra-high-density traffic control covering 150 stations and 572 km of lines throughout the Tokyo metropolitan and suburban area. ATOS provides real-time information for passengers as well as train control.

We had to take some concepts into account when we designed this new system named an ATOS-PDA system. First, we employ general-purpose cellular networks and general-purpose PDAs for the station staffs moving around in a station. Second, we must keep security for the ATOS, which manages important train control in Tokyo, to protect it against hackers who can illegally access the ATOS network through the cellular networks. Third, we introduced web-based screen layouts for the contents, written with HTML, because HTML does not depend on the hardware for the PDAs.

ASCAP Parameter Determination by an Intelligent Genetic Algorithm

Weidong Ruan, Theo C. Giras and **Zongli Lin**, University of Virginia

ASCAP, the Axiomatic Safety-Critical Assessment Process, is a rail system simulator being developed at the Center of Rail Safety-Critical Excellence at the University of Virginia. It determines the reliability and safety of a given train control system via discrete event simulation. An important component of the ASCAP is the traffic management algorithm (TMA), which simulates various aspects of the train movement including train trip time. The actual trip time of a train after its dispatch is determined by the train-block-average-speeds and delays occurred at the sidings. Data on these train travel schedule parameters are however expensive to collect and, as a result, are scarce for many rail systems currently in service. Simulation of the train travel schedule based on these limited data proves a significant challenge.

This paper reports on a successful determination of the train travel schedule parameters for a rail system based on limited data. The train system considered is a CSX-owned corridor, stretching from Spartanburg, SC to Augusta, GA, and encompassing a territory of over 120 miles. It is divided into 37 train speed blocks, with 9 sidings. The only data available are the actual trip times of 171 trains dispatched over a period of 14 days. We formulated the problem of determining the 37 train-block-average-speeds and 9 siding delay times as a constrained optimization problem. The cost to be minimized is the cumulated errors between the actual train trip times and the ASCAP simulated trip times resulting from a particular set of train-block-average-speeds and siding delay times. The constraints include allowable siding

delays, permissible train-block-average-speeds and prohibition of southbound trains from entering the sidings. This large scale nonlinear optimization problem was then solved by a genetic algorithm we developed and referred to as the intelligent genetic algorithm. Simulation results demonstrate the effectiveness of our approach.

Dynamically Complex Rail Projects – A Systems Engineering View

Jim Brunton and **Kevin Tarling**, Parsons Brinckerhoff Ltd, UK

A large percentage of new projects are upgrades of the existing rail infrastructure and require that the works be undertaken with little or no disruption to the existing operational railway.

Programme objectives require a fully integrated railway infrastructure design to be developed to a level sufficient to support the design and implementation process required by the infrastructure owners, and obtain acceptance from the Railway Safety Authority. Often, the infrastructure providers client team are responsible for the preparation of specifications and designs of sufficient detail and clarity to enable each of the designated main contractors to confidently provide target costs and undertake detail design and implementation work that meets the project requirements as defined by the Sponsor. However, this creates a large number of interfaces and consequently increases the risk (both technical and commercial) as interfaces are generally the source of ambiguity.

The programme works are generally straightforward from a detail technical design aspect, however, due to the large of amount of design interfaces and the interaction required on site, due to the large number of work packages that are normally required for an operational railway, there is a large degree of dynamic complexity.

This paper provides a pragmatic view of the Systems Engineering aspects of large infrastructure projects based on the authors experience in the UK and overseas on rail and other projects. It describes how the complex interaction and interfacing between all the various parties is being managed with a particular focus on the Requirements Management process and tools.

Simulation and Emulation of Rapid Transit DC Short Circuit Current

Bih-Yuan Ku, National Taipei University of Technology, Taiwan

In this paper we present a new tool for MRT DC short circuit current simulation and current waveform emulation. This portable system incorporates a simulation program and the hardware analog output interface to produce DC short current waveforms for various operation conditions, making it suitable for relay parameter setting and function testing purposes before and after commissioning.

In DC Transit power systems close-up faults produce large short circuit like AC power systems and hence can be easily detected by current magnitude. Yet the magnitudes of remote fault currents are usually less than that of normal train staring current due to high series impedance of the third rail, the running rails, and possibly the fault itself. Therefore, DC short circuit profile at various locations under different operating conditions must be established in order to obtain correct protection equipment settings. Moreover, it is required that short-circuit tests be performed to verify the calculations.

The traditional approach of DC transit traction power system short circuit calculation is based on the simplified constant DC voltage source and constant impedance model. For accurate DC short-circuit computation the issues of voltage regulation and frequency dependence of impedance must be addressed and included. In this paper we present a DC short-circuit simulation program using Matlab/Simulink that can readily include the characteristics of rectifier voltage regulation and frequency dependence of traction system impedance. The simulation results can be directly output through a D/A(digital to analog) interface card to produce short-circuit current waveforms similar to those generated by MIU (measurement/ instrument unit) to test computer relays. The whole system is implemented on a notebook computer, making it suitable for relay parameter setting and function testing purposes. This system can be used by DC traction engineers to obtain initial settings for computer relays of DC traction power systems before commissioning. It can also be applied to routine testing of computer relays for transit line operators, and to adjust relay settings should there be modifications in transit line traction power system configuration.

Light Rail Systems without Wires?

John D. Swanson, Parsons Brinckerhoff Transit and Rail Systems

For over 110 years, the use of overhead wires to power streetcars and more recently their successors, light rail vehicles, has considered unsightly and undesirable by politicians and the general public alike. At the turn of the century many cities passed ordinances against them and many alternative power feed concepts were attempted, the most successful being the slot or conduit system used in New York City, Paris, London and Washington, D.C. as late as 1963. In the end however, overhead wire (OCS) systems proved to be the most reliable and are now used on all light rail systems worldwide. The dream of having a "wireless" system has not died, and in recent years, new technological developments in fuel cells, flywheels, micro-turbines, batteries, hybrids and various ground level switched contact systems such as STREAM, INNORAIL, and ALISS are showing signs of offering a practical alternative to overhead catenary systems. The latest new developments worldwide will be examined, including operational experience, cost, weight and space impact for each of the alternative systems. Of particular interest are European developments in hybrid light rail vehicles in Karlsruhe, Germany with the ULEV-TAP research program and the cutting edge INNORAIL ground level switched contact system currently being installed over nearly half the new light rail system in Bordeaux, France. From these comparisons, we can conclude that practical alternatives to overhead wires for light rail systems are at last becoming service proven and commercially available.

Safety-Critical Analysis of Vortex Shedding Induced Vertical Motion of Magnetic Levitation Systems in Maglev Vehicles

P. Allaire, T. Giras, B. Huang, Z. Lin & Y. Cao, University of Virginia

Maglev trains, such as the Transrapid maglev system, have nonlinear attractive magnetic levitation systems that have advanced magnetic gap control systems. There are a number of potential accident pairs that should be investigated to take a proactive approach to safety critical system operation. A mathematical model of the vehicle coach body, bogie, coach spring and damper suspension, and attractive magnetic suspension system undergoing vertical motions subject to exter-

nal excitations is developed. Realistic typical values for the system are employed in simulations. Both linear and nonlinear magnetic suspension current control algorithms are evaluated with regard to system stability and forced response. Bogie motions have severe geometric limitations due to typical suspension airgaps of 10 mm as well as other limiting factors. Advanced control design for the magnetic levitation system, taking into account the available airgap limitations, can take advantage of robust control algorithms for system stability and forced response due to external disturbances.

The primary objective of this paper is to establish some advanced safety-critical analysis of a potential accident-pair that has not previously been considered in depth. One potential vehicle-guideway accident-pair discussed in this paper is the effect of high velocity side winds on the vehicle, such as might be encountered in a large wind storm, are evaluated with regard to vortex shedding excitations. The maglev system guideway is much more elevated than conventional rail lines and the magnetic suspension is significantly less stiff than a conventional wheel/rail interface leading to the need for safety critical assessment in this case. Both the effects of vortex shedding resonance conditions and force levels are investigated to evaluate the potential for contact between the vehicle and guideway. The ability of the magnetic levitation system to avoid vehicle bogie-guideway contact is investigated.

Transverse Bounce and Roll Motions in Maglev Vehicle Suspension and Current Control for Safety-Critical Analysis

Z. Lin, B. Huang, T. Giras, P. Allaire & **Y. Cao**, University of Virginia

Safety critical analysis of maglev vehicle systems is very important for proactive actions to assure modified operation to fail-safe conditions. This paper considers a mechanical-magnetic model of the vehicle coach body and bogie undergoing transverse motions, both vertical displacements (bounce mode) and angular displacements (roll mode) subject to external force and moment excitations similar to the Transrapid maglev system. A nonlinear state space model of the coach body, coach spring and damper suspension, bogie and attractive magnetic suspension system is developed with typical system parameters. The model parameters are similar to those in the Transrapid maglev suspension system. The performance of both linear and nonlinear current control methods to stablize the suspension as well as remain robust when encountering force and moment disturbances is examined.

A potential accident-pair concerns vehicle-guideway interactions when subject to both vertical and angular guideway misalignments. These misalignments may be due to earthquakes or ground subsidence such as due to underground mine collapse. Severe guideway-vehicle airgap constraints exist which are taken into account for this safety critical analysis. Matlab Simulink transient simulations are employed to evaluate the capability of the two current control systems, one on each side of the vehicle, to avoid contact between the bogie and guideway. With proper system analysis, the movement of the system to fail-safe operation within certain guide misalignment limits are evaluated.

Symbol-by-Symbol Rate Adapting Wireless Communication Systems

Lih-feng Tsaur & **Daniel C. Lee**, University of Southern California

When accessing a wireless communication network in a moving vehicle, the communication stations have to decode the message carried by the fading signal caused by Doppler effects. In a high-speed vehicle such as in a moving train, the received signal strength fluctuates more rapidly than in a slow vehicle. The observed range of fluctuation can be as large as 40dB, and the period is around twice the inverse of maximal Doppler frequency. This fast fluctuation on SNR level will degrade the performance of the current frame-based rate adaptive system in high-speed traveling system. We construct the following example to illustrate the problem. Consider a train traveling at 60 mile per hours and the carrier frequency is 1 GHz. The maximal Doppler frequency is then around 90 Hz. Consequently, the period of the quasi-periodic fluctuation of the channel quality is about 190Hz; or, equivalently, the period is around 5ms. The frame-by-frame rate adaptation scheme, which is currently used, cannot respond rapidly to the quickly fluctuating channel qualities because the frame duration is much longer than the period of the channel fluctuation. Moreover, as the maximal Doppler frequency is linearly proportional to the carrier frequency and the vehicular speed, the current frame-based rate adaptive system becomes less suitable for the high-speed railroad system. To resolve the problem, we develop the novel symbol-based rate adaptive system, which allows the station to adjust the symbol rate in microsecond range.

We present a complete feedback system architecture for our symbol-based rate adaptive systems. In particular, we present the design of the coded-signal and the adaptation schemes that enable stations to adjust the symbol rate or other resources without out-of-band signaling. Without the extra operation latency, the stations can rapidly change the symbol rate or other resources according to channel's condition in high-speed systems. This enables the communicating stations to improve the channel capacity and/or maintaining the signal integrity.

Voltage Flicker Calculations for Single-Phase AC Railroad Electrification Systems

Tristan Kneschke, P. E., LTK Engineering Services

Rapid load variations can cause abrupt changes in the utility voltage, so-called voltage flicker. The voltage flicker may result in light flickering and, in extreme cases, damage to electronic equipment. Electrified railroads are just one example where such rapid load variation occurs as trains accelerate, decelerate, and encounter and leave grades.

For balanced loads, the voltage flicker is easily determined using per-phase analysis. AC electrification system substations operating at a commercial frequency, however, are supplied from only two phases of utility three-phase transmission system. In order to calculate the voltage flicker for such an unbalanced system, Symmetrical Component Method needs to be used.

In this paper, a procedure is developed for evaluating the effects of short-time traction load variation onto utility system. Applying the Symmetrical Component Method, voltage flicker equations are developed for loads connected to A-B, B-C, and C-A phases of a three-phase utility system. Using a specially-developed software simulating the train and electrification system performance, loads at the traction power substation transformers are calculated in one-second intervals. Subsequently, voltages at the utility busbars are calculated for each interval, and the voltage variation from interval to interval is expressed in percent.

The calculated voltage flicker is then compared to the utility accepted limits. Based on this comparison, the capability of the utility power system to support the traction

loads can be assessed and the suitability of the proposed line taps for the traction power substations confirmed.

Overhead Conductor Selection Based on Transient Current and Temperature Analysis for Better Electrification System Economics

Tristan Kneschke, P. E., LTK Engineering Services

Power demand of traction power supply systems is rapidly fluctuating as trains accelerate and decelerate, as route gradients change, and as the trains enter and leave power distribution sections. This fluctuating load needs to be delivered to the trains by overhead distribution system conductors and, therefore, the conductors need to be adequately sized for the envisaged current profile to prevent conductor overheating, annealing, and damage.

Two methods of evaluating conductor current-temperature relationship are available, steady-state and transient. The steady-state approach of determining the conductor steady-state currents, and then selecting conductor sizes based on their ampacities, could result in oversizing of conductors and an uneconomical system.

The transient method is more appropriate for fluctuating loads. First, transient current profiles of conductors based on traction power load-flow simulations of future train operation are determined versus time. Subsequently, temperature profiles corresponding to the current variations are developed for proposed combination of conductors. Only the conductors operating at below the temperature limit advised by conductor manufacturer should be selected.

A procedure for evaluating transient conductor temperatures taking into account current fluctuations is developed and demonstrated on several typical examples. Based on the evaluations, suggestions for selection of appropriate conductor sizes that would result in more economic electrification system designs are provided.

Conferences of Interest

The following table shows VT-06 sponsored and co-sponsored conferences as well as related conferences not sponsored by the Society. While every attempt was made to ensure accuracy, you should contact the respective conference committee to confirm date and location.

DATE	CONFERENCE	LOCATION	WEB PAGE	
24-26 March 2003	Int. Symp. On Wireless Systems and Networks (ISWSN'03)	Dhahran, Saudi Arabia	http://users.kfupm.edu.sa/iswsn03/	
22-24 April 2003	JRC 2003	Chicago, IL	See Page 43	
22-25 April 2003	VTC 2003-Spring	Jeju, Korea	http://www.vtc2003spring.org/	
22-25 April 2003	EPMCC2003	Glasgow, Scotland	http://www.epmcc.com	
11-15 May 2003	ICC2003	Anchorage, AK	http://www.icc2003.com	
1-3 June 2003	MobiHoc 2003	Annapolis, MD	http://www.sigmobile.org/mobihoc/2003/	
15-18 June 2003	SPAWC2003	Rome, Italy	http:// www.spawc2003.it	
15-18 June 2003	IST Summit	Aveiro, Portugal	http://www.mobilesummit2003.org/	
23-27 June 2003	APS International Symposium/ URSI Radio Science Meeting	Columbus, OH	http://aps2003.eng.ohio-state.edu/	
7-9 July 2003	Wireless 2003	Calgary, Alberta	http://www.cal.trlabs.ca/wireless/	✓
14-16 July 2003	WOC 2003	Banff, Alberta	http://www.iasted.org/conferences/2003/banff/woc.htm	✓
7-10 September 2003	PIMRC 2003	Beijing, China	http://www.pimrc2003.org	✓
17-19 September 2003	MC-SS 2003	Oberpfaffenhofen, Germany	http://www.dlr.de/kn/kn-s/mcss2003	✓
4-9 October 2003	VTC 2003-Fall	Lake Buena Vista, FL	http://www.vtc2003.org	✓
19-22 October 2003	WPMC'03	Yokosuka, Japan	http://www.ilcc.com/WPMC/	✓
1-5 December 2003	Globecom 2003	San Francisco, CA	http://www.globecom2003.com	
Spring 2004	VTC 2004-Spring	Genoa, Italy	mailto:vatalaro@ing.uniroma2.it	✓
20-24 June 2004	ICC 2004	Paris, France	http://www.icc2004.org	
26-29 September 2004	VTC 2004-Fall	Los Angeles, CA	mailto:Sumner.S.Matsunaga@aero.org	
29 May – 1 June 2005	VTC 2005-Spring	Stockholm, Sweden	mailto:Jens.Zander@radio.kth.se	
Q2 2006	VTC-2006 Spring	Melbourne, Australia	mailto:fzheng@ieee.org	

Conferences marked '✓' have open calls for papers as of 14 February 2003. This list is based upon the conference calendar at our web site, which is updated more frequently than this list can be. To access it go to the following URL: http://www.vtsociety.org/, then click on "Conference List" in the left frame.

Corrections and additions to this list are most welcome. We are particularly interested in adding listings for Automotive and Transportation conferences. Please send corrections and additions to Tom Rubinstein at t.rubinstein@ieee.org.

Answer to the history question: Bill Fleming's first column was in August 1974, when the *VTS News* was called *The Vehicular Technology Group Newsletter.* He has contributed to almost every issue since, clocking up more than 100 columns.

IEEE/ASME JOINT RAIL CONFERENCE

APRIL 22nd, 23rd, and 24th, 2003

CONFERENCE REGISTRATION

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Payment by check or money order (U.S. currency) made payable to **"2003 IEEE/ASME Joint Rail Conference"**. Also, VISA, MasterCard and American Express accepted.

Advance registration must be received by April 20th, 2003.

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TECHNICAL TOUR	YES	NO

* Member fee applies to Session Chairman and Authors.
** Non-members who pay full Conference rate will be eligible for one year free Membership in the IEEE or ASME (as applicable) if they fill out the application form.
*** Additional Luncheon Tickets and Proceedings will be available at the Registration Desk.

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IEEE/ASME JOINT RAIL CONFERENCE

APRIL 22nd, 23rd, and 24th, 2003

HOTEL RESERVATION

MAIL OR FAX RESERVATIONS TO:

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Please communicate directly with the W Hotel using this form or by phone. When you make your reservations by telephone ask for the Reservations Desk and identify with **2003 IEEE/ASME Joint Rail Conference** to obtain the special room rate.

Room Rate is $165.00 Single night plus 14.9% tax.
Please circle accommodation required.
Single Double Smoking Non-smoking

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Reservations must be received no later than 5:00 p.m. on **March 23rd, 2003**. After this date, rooms will be reserved on a space available basis. All major credit cards accepted. Suggested check-in time is after 3:00 p.m. Checkout is 12:00 noon. For arrival after 3:00 p.m., a reservation guarantee by a major credit card is required.

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TRANSPORTATION

The CTA runs to the Loop from O'Hare and Midway Airports. From O'Hare to Monroe on the Blue Line the Hotel is two and a half blocks away. From Midway to Quincy on the Orange Line the Hotel is half a block away. The Hotel is three and a half blocks away across the Chicago River from Union Station.

LOCATION

The Hotel is located in the heart of Chicago across from the Sears Tower. It is four blocks from The Chicago Art Institute and seconds from State Street (that great street!!!).

TECHNICAL TOUR

A technical tour is planned for the afternoon of Tuesday, April 22nd, to the CTA Skokie Shop Rail Heavy Maintenance Facility. Final details will appear in the advance program.

PROGRAM

An advance program will be mailed to members in February 2003.