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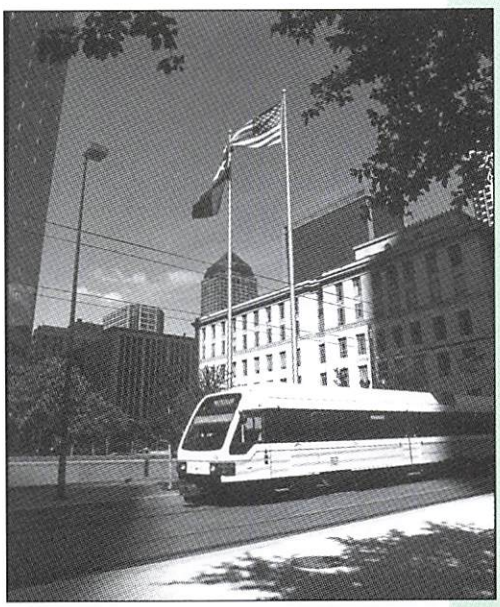

DART Rail in downtown Dallas. VTC visits Dallas in September – see Page 41. Photo Dallas Area Rapid Transit

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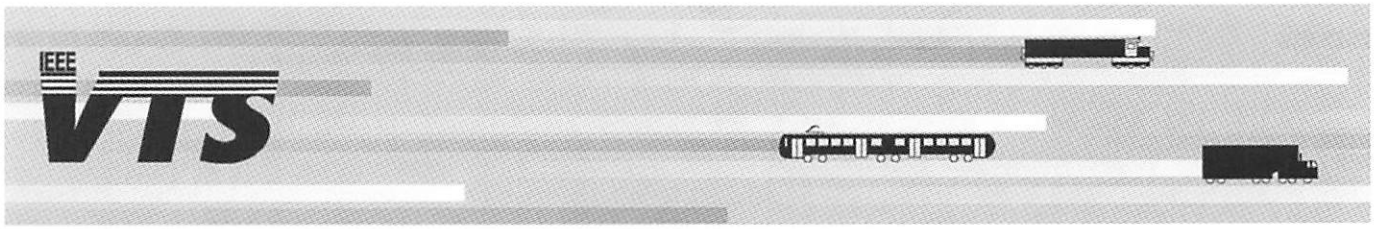

Foreword

James Irvine, Editor

Big changes are on the cards for the VTS News. At the June Board series, TAB approved the Society's proposal that the VTS News be transformed into a magazine from the start of 2006. This is the culmination of a two year process which will see the replacement of the newsletter with a quarterly 64-page magazine, offering scope for 50% more content and better production and editorial standards with the introduction of full colour throughout.

We intend to keep the best parts of the VTS News and improve on them. The columns on the different technology areas will be retained, but the use of full colour will improve their reproduction. The society columns are being restructured under the leadership of former president Charles Backof, with more coverage of conferences, chapters and educational activities. However, most of the new editorial space will go to increase the number and breadth of our feature articles. These will also benefit from the use of colour and graphic design.

As part of the Society's commitment to its members, the new magazine will go to all members as part of the existing $18 membership fee, and as such will be a direct replacement for the newsletter. The magazine will have slightly longer lead times than the newsletter, so the current February, May, August and November schedule will be replaced by March, June, September and December. The first issue will therefore be March 2006. It will be bundled with a DVD archive containing all the Society's Transactions and Conference papers back to 1951, another part of a programme to return greater value to members.

To allow more time for the changeover, the August and November issues of the VTS News will be combined, and will be sent as a specially extended issue at the end of October. The first issue of the VT Magazine will follow at the end of February.

All of us on the editorial team of the VTS News are excited about the new opportunities which transitioning to a magazine will bring. We hope that in its new guise it will serve Society members for another 52 years.

Copy for the last issue of the VTS News should reach Dr. James Irvine by September 4, 2005. at Mobile Communications Group, EEE, Strathclyde University, George Street, Glasgow G1 1XW Scotland,
E mail: j.m.irvine @ieee.org.
Copy dates for the VT Magazine are as follows:

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March 2006	December 4, 2005
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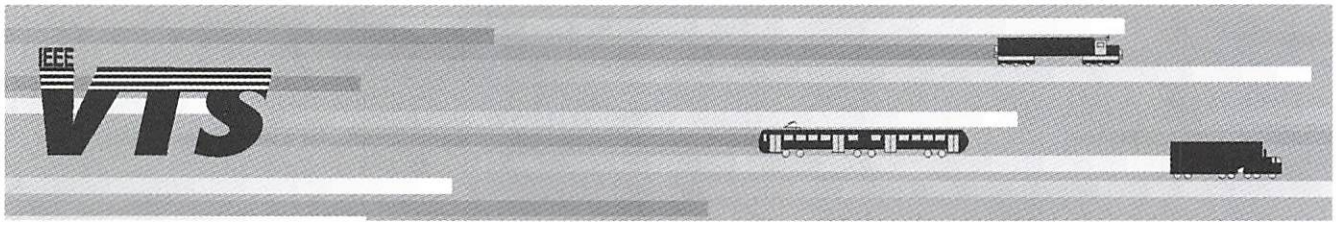

Mobile Broadband Systems: Research and Visions

Fernando J. Velez, University of Beira Interior, Manuel Dinis, Portugal Telecom Inovação S.A., José Fernandes, University of Aveiro

This article gives an overview of the European research on Mobile Broadband Systems (MBS), whose features range from WLANs type scenarios, allowing low mobility and medium data rates, up to public cellular MBS, where high mobility and data rates are foreseen, leading to plain ubiquity. Current trends in 4G systems are described leading to the definition of the MBS concept. Owing to high transmission data rate and spectrum limitations at lower frequency bands, MBS intend also to operate at millimetrewave frequency bands, namely the 40 and 60 GHz, offering improved system capacity. The MBS concept and the Trial Platform developed in the framework of the European ACTS-SAMBA and RACE-MBS projects are presented. Cellular planning aspects are discussed including a comparison between the 40GHz and 60GHz bands, considering services and applications, tele-traffic, and MBS optimisation based on economics aspects. Field trials results on the radio interface performance are presented, demonstrating MBS cellular operation feasibility at millimetrewave frequency bands.

Introduction

The paradigm behind 3G is the widespread provision of multimedia services and applications to users while on the move, therefore adding a multimedia flavor to the "anytime and anywhere" concept. In that regard, wideband and broadband radio technologies are necessary and a panoply of enhanced color displays, multimode, and multiband terminals will be required to satisfy market needs. The seamless transition between the respective environments, a good QoS (Quality of Service), and complete freedom, leading to full competition and new business models are other issues to be addressed and incorporated in future mobile systems. Further research and technology developments will contribute to an increase in the maximum transmission bit rates, to the convergence of the various access technologies associated with the seamless access paradigm, and to network evolution towards "all IP", which will reduce network deployment costs. Moreover, terminals will evolve to radio reconfigurability, allowing for operation on a family of access technologies and networks.

The large demand that is foreseen for really broadband mobile multimedia services in the next years and the current limitations on achievable data rates and system capacity, leads to the continuous research on mobile systems and eventually, to the deployment of cellular Mobile Broadband Systems (MBS) operating as well at millimetrewave bands [1]. In Fig. 1 an attempt is made to compare nowadays and future generation mobile systems in terms of data rates and mobility.

MBS are shown to exist in full operation beyond 4G and ending the "generation game" that today exists in the mobile communications industry. This idea is supported on the fact that after 4G there will be a full convergence of networks (fixed, mobile and wireless) and a complete integration of the different access technologies, leading to a completely ubiquitous telecommunications system. Extremely high data rates, approaching those nowadays available in fixed networks, combined with a high mobility, will be offered by MBS. These systems will operate in many frequency bands, including the millimetrewave ones, where bandwidth is not a serious issue as in lower frequency bands (around 1-2 GHz). It will exist everywhere providing seamless roaming between different access technologies to users, and enough capacity at low cost per bit, for the provision of huge amount of information, applications and broadband services to MBS users.

Historically, under the European RACE Programme initiatives in mobile cellular communication systems, a first definition of MBS and related systems was presented assuming that, in terms of terminal mobility and supported data rates, MBS operation will just begin where 3G ends. Reality has shown that another step is needed (the 4G) before we can have and experience MBS. The foundation of the MBS concept and its evolution is presented in [2].

MBS comprise a different set of integrated technologies, ranging from WLANs type environments, allowing low mobility and medium data rates, up to public cellular networks, where high mobility and high data rates are foreseen. The first MBS networks will use the lower frequency bands, and tend to address environments where mobility is low or just allowing portability. Therefore, MBS services will be first offered in WLAN type of scenarios.

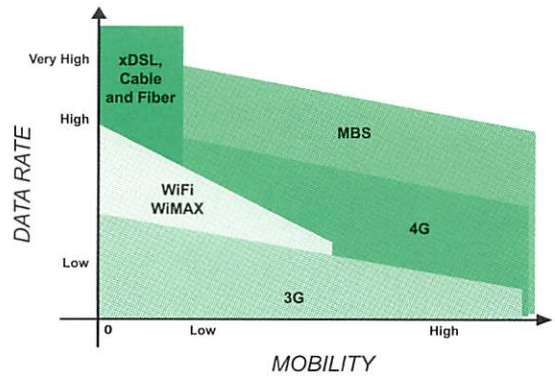

Figure 1. *3G, 4G and MBS capabilities.*

Later, when full deployment is required, there will be other possibilities in the 17, 40, and 60 GHz frequency bands. In these bands, high mobility, outdoor and indoor coverage will be supported.

This article focuses on MBS operating in the millimetrewave frequency bands and is organised as follows: Section 2, makes a summary of the current research focus in Europe towards 4G. Section 3 presents the MBS millimetrewave bands key aspects and issues, while in Section 4, aspects of cellular coverage and frequency reuse are discussed from the point of view of large-scale cellular planning. Besides, aspects related to services and applications, tele-traffic, and cost/revenue optimisation issues of MBS are briefly addressed. In Section 5, the trial platform built up in the framework of the European SAMBA project is presented, namely the air interface and cell coverage issues. Results of the field trials in an outdoor scenario are presented, namely BER (Bit Error Rate), and received signal power. Conclusions are drawn in Section 6.

Current Research Directions

Due to the difficulties that the millimetrewave frequency bands present to mobile communication systems, and the actual cost of the required technology, current research focus exploits a wide variety of enhancements to 3G systems, applicable to bands up to about 6 GHz. These are the frequency bands expected for 4G systems operation. One of the most important projects contributing to the definition of the radio aspects of 4G systems in Europe is WINNER (Wireless World Initiative New Radio) [3].

The vision of WINNER for mobile radio communications beyond 3G is of a ubiquitous radio system concept, operating at frequencies lower than 6 GHz, and covering the full range of scenarios from short-range to wide-area, which provides a significant improvement compared to current systems in terms of performance, efficiency, coverage and flexibility. WINNER addresses a ubiquitous radio system concept based on common radio access technologies that will adapt to and be driven by different user needs and scenarios, by utilising advanced and flexible network topologies, physical layer technologies and frequency sharing methods. The ubiquitous radio system concept will make efficient use of the radio spectrum to minimise the cost-per-bit by utilising the technologies researched within the WINNER project and combining them in an efficient way.

Scenarios include:

- In building, with low mobility, small cell sizes.
- Public hotspot/area, with low-medium mobility, and cell range of ~ 100 m.
- Urban/suburban, where higher mobility is allowed in cells up to 500 m.
- Rural (high speed), where high mobility is allowed in cells that range from 1 to 10 km.

Link data rate will generally be up to 100 Mb/s, except in the case of the "in building" scenario, where it can reach 250 Mb/s. Cell throughput will be 1 Gb/s in low/medium mobility scenarios, and 1 Mb/s in higher mobility scenarios.

MBS at Millimetrewave Bands

Nowadays, while the wideband segment of mobile communications is being supported by UMTS and its enhancements (e.g., HSDPA, High Speed Downlink Packet Access), truly broadband requires MBS. Along the last decade, European research projects have given contributions that allowed for the creation of the MBS concept, and contributed for the developments of the new associated technologies. The RACE-MBS and ACTS-SAMBA projects developed different demonstrators for MBS evaluation. The RACE-MBS demonstrator operated at the 60 GHz band while the ACTS-SAMBA operated at the 40 GHz band.

The primary goal of ACTS-SAMBA project was to promote the development of a broadband cellular radio extension to the fixed broadband network, thus, allowing the use of fully interactive broadband multimedia services by mobile users. The project focused on a trial platform [4], which intended to demonstrate the MBS feasibility at the 40 GHz millimetrewave frequency band.

Owing to their high transmission data rate and due to the saturation of the spectrum at lower frequency bands, MBS are intended to operate in the millimetre waveband, offering improved performance in system capacity. At the millimetrewave bands, due to the specific characteristics of the radio channel, sophisticated mitigation techniques are required to improve the performance of MBS. The used data needs to be converted to a suitable form to keep the number of transmission errors at an acceptable level, taking into account for the specific frequency band used, the environment and mobility of terminals or obstacles. To mitigate the effects of shadowing, multipath propagation, and time variance due to motion (causing large-scale and small-scale fading), and to approach the system performance near to AWGN (Additive White Gaussian Noise) channel conditions, various possibilities were identified: adaptive equalisation techniques for single carrier modulation, multicarrier or OFDM (Orthogonal Frequency Division Multiplexing) modulation, error-correction coding, interleaving, robust modulation, utilisation of directive antennas, and diversity reception. An extensive discussion on the aspects of characterisation of the radio channel is presented in [5].

Due to the high path loss and obstacles opacity to the electromagnetic waves at high frequencies, LoS operation is normally required. This limitation can be reduced by the utilisation of multiple cell coverage configurations, e.g., two BSs allow to overcome the shadow regions. This solution requires however the installation of more BSs affecting directly the network cost [6].

The following specific bands are being considered for the implementation of MBS: [39.5, 43.5] and [62, 66] GHz, with an interval of 2 GHz in between 1 GHz bands, Fig. 2. Propagation characteristics are not the same in these two bands, with oxygen and rain presenting different values for their attenuation coefficients; moreover, these coefficients are not uniform within each of the bands. Since a larger attenuation leads to the possibility of reusing frequencies at a closer distance for approximately the same coverage (the attenuation is not substantial for short distances like the ones involved in cell coverage), the usage of one or the other frequency bands can have significant consequences on system capacity.

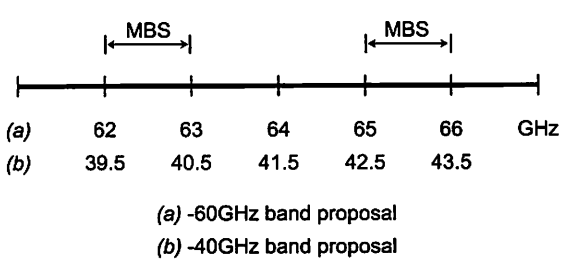

***Figure 2.** Millimetrewave bands foreseen for MBS implementation.*

Cellular Planning at 40 GHz and 60GHz

The 40 and 60 GHz bands are different from the UHF bands, since the attenuation from atmospheric elements, namely rain and oxygen has to be taken into account. Besides, the desired high capacity leads, in conjunction with the low values for the achievable transmitter power, to micro-cellular architectures, employing a large number of cells, with BSs deployed at relatively low heights above ground level (e.g., around 5 m, in lamp posts). As a consequence of all these peculiarities, it makes sense to compare the two bands from the point of both cell coverage and frequency reuse.

Cell Geometries and Layouts

As propagation occurs essentially in line-of-sight (LOS) the shape of the cells and the co-channel interference are determined, to a large extent, by the location of the surrounding objects, buildings in particular (in urban outdoors scenarios). As a consequence, for cellular design purposes, an easy analytical treatment is only possible for environments with a regular structure as the linear and the "Manhattan grid" (planar regular) geometries.

For this regular geometries one can follow classical frequency reuse approaches that establish the correspondence between, on the one hand, the maximum coverage and reuse distances, R and D, and, on the other hand, the interference-to-noise ratio, I/N, and the carrier-to-interference ratio, C/I, for both bands, and extract conclusions about the range of coverage distances that allows us to obtain minimum values for the co-channel reuse factor (computed from D), and under which conditions it is preferable to use one band or another [7].

For urban irregular geometries, conclusions on the quantities of interest related to cellular design, such as urban coverage, achievable frequency reuse and system capacity, can be obtained from specific cellular layouts and environments (but typical, as much as possible). This can be done by using the interactive cellular planning tool (developed during the RACE-MBS project) to assist in the design procedure [8]. The planning tool allows for the interactive placement of BSs over a map of an area to be covered, determines the coverage area for each cell, and the interference among cells, taking LoS into account, through algorithms for the computation of visibility polygons/chains. These results can be fed into frequency assignment algorithms for the determination of the reuse factor and system capacity.

Average Received Power

At the millimetrewave bands the average power received at a distance d from a transmitter can be found by considering an almost free space received power, plus the attenuation due to oxygen and rain [9]. The crucial parameter for this model is the average power decay exponent, n, since all the others are well known. Values for n have been presented in the literature, ranging from 1.4 to 2.5 [10]. For an outdoor environment n is in the range [2.0, 2.5], a value of n = 2.3 being typically used [9]. There is only a small difference for the free space path loss between both bands, approximately equal to 20?log(60/40) = 3.5 dB; therefore, it is obvious that the difference between the two bands is not imposed by this parameter.

For the oxygen absorption, however, the difference is relevant. Using the equations of ITU-R [11] for f < 57 GHz and the formulas presented in [9] for 60 ≤ f ≤ 66 GHz, one obtains the curves presented in Fig. 3, where the frequency scale is normalised in order to superimpose the 40 and 60 GHz bands in the same graph (-2 GHz corresponds then to the lower limit of each band, 39.5 or 62 GHz respectively, and 2 GHz to the upper one). In the 40 GHz band, go is almost constant and negligible (less than 0.07 dB/km), whereas, in the 60 GHz band, it has to be considered, decreasing from 14 dB/km (at 62 GHz) down to approximately 1 dB/km (at 66 GHz). In the case of the higher frequency band, the additional path loss caused by the oxygen absorption is negligible for short coverage distances, but it can present high values, larger than 10 dB, for typical reuse distances.

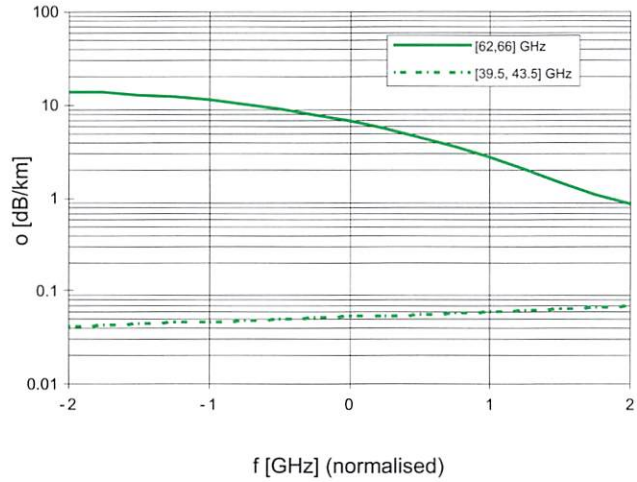

Figure 3. Oxygen attenuation coefficient as a function of normalised frequency for the 40 and 60 GHz bands (0 corresponds to the central frequency of each band).

Rain attenuation has also to be considered, and the model presented by ITU-R [12] has been used. For a rain intensity of 30 mm/h, which occurs in Europe with a probability less than 0.03% (circa 2 h 38 m per year), the rain attenuation is approximately 8 dB/km in the 40 GHz band, and it is slightly increasing through the band; in the 60 GHz band, the behaviour is similar, with a value of the order of 12 dB/km. Nevertheless, the difference between the two bands is not as significant as the one concerning oxygen. A more detailed analysis can be found in [7].

Comparison between the 40 and 60 GHz bands

It is well known that the attempt to reuse each frequency to a maximum in close cells is limited by the interference between co-channel cells. In regular structured environments it is important to establish the correspondence between the maximum coverage and reuse distances, R and D, and the CIR, C/I, for both bands, and to analyse the resulting consequences, in order to decide in which conditions is preferable to use one band or another. The simplest geometry to study the problem of frequency reuse in a cellular system is the one corresponding to a pair of cell, where only two co-cells exist with maximum coverage distance R and with their centres separated by a distance D (see Figure 4).

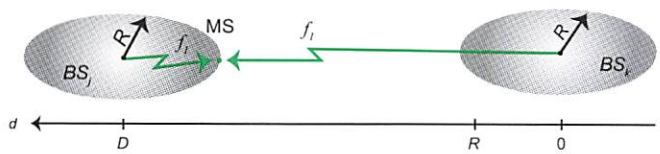

Figure 4. Geometry for a pair of interfering cells.

The C/I ratio has a direct influence on the co-channel reuse factor, rcc, and on system capacity. Considering two co-cells, the minimum value for C/I is given [9]

$$C/I_{[dB]} = \gamma \bullet (r_{cc} - 2) \bullet R + 10 \bullet n \bullet \log(r_{cc} - 1), \quad (1)$$

where represents the attenuation by atmospheric elements, $= o + r$, and r_{cc} = D/R; the usual assumptions for C/I analysis have been considered (concerning transmitted power, antenna gains, and so on). In this ideal situation, where thermal noise is not considered, the dependence of C/I on rcc has, on one hand, a logarithmic term that depends on the average power decay exponent, and, on the other hand, a linear term that depends on the oxygen and rain attenuations, and on the coverage distance as well. As the same average power decay exponent is considered for both the 40 and 60 GHz bands [9], the difference between them is mainly due to different values of the oxygen and rain attenuation coefficients. At 40 GHz (where the oxygen absorption is negligible), if rain is not considered only the logarithmic term remains (Figure 5). A case of invariance to linear scaling of reuse and coverage distances will occur, since C/I will only depend on r_{cc} = D/R, presenting values of the order of 16 dB for r_{cc} = 6, both at 39.5 GHz and 43.5 GHz. These values and behaviour are similar to those found in the UHF band. In the other cases (40 GHz with rain, or 60 GHz – either with or without rain), however, the linear term will not be negligible, and the conclusions will be different. Details can be found in [7], where the analysis of the linear (the coverage of an indefinitely long street or highway) and "Manhattan grid" (a regular urban geometry with streets perpendicular to each other) regular structures is explored, too, and the simultaneous effect of noise and interference is analysed.

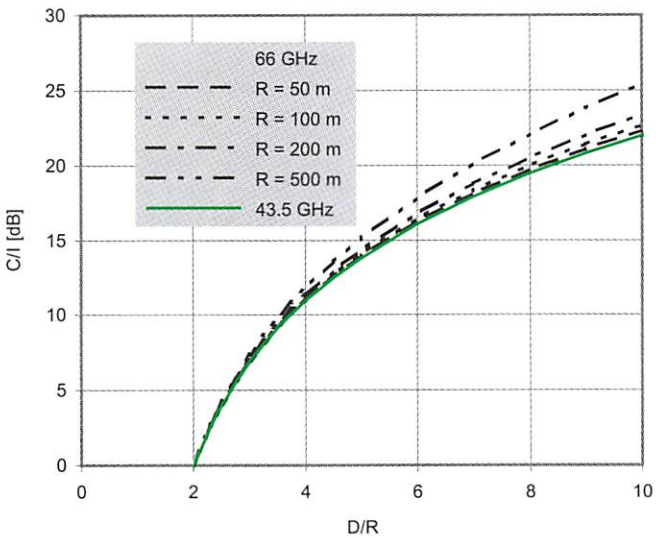

Figure 5. *Carrier-to-interference ratio in terms of the co-channel reuse factor, with R as a parameter, in the absence of rain.*

In this case, for both linear and planar regular geometries, different values for r_{cc} result at 43.5 and 66 GHz, being slightly higher for the former. However, for these regular geometries, as the co-channel reuse factor needs to be even, no practical difference exist on the values of co-channel reuse factor, and of the reuse pattern, K, between the two bands (r_{cc} = 6 and K = 3 in both) because the presence of obstructions decrease considerably the degree of interference between cells. A difference, however, exist in the achievable maximum coverage distances, values at 43.5 GHz being more than 20 % larger than at 66 GHz.

In [7], cellular planning results in specific irregular urban geometries were obtained using the planning tool developed during RACE-MBS [8]. An application was made to the coverage of part of Lisbon by MBS operating at the 40 and 60 GHz bands. Reuse patterns in the range 5-11 were obtained, with smaller values corresponding to smaller cell sizes, and vice-versa. The use of the 60 GHz band may lead to higher system capacity but it depends on the exact implementation to be done.

Services and Tele-traffic

In [13], MBS scenarios of operation were defined by incorporating a complete classification of MBS services and applications, their characterisation parameters, and available forecast information. As multi-service traffic analysis requires the definition of the main operation environments, the respective deployment scenarios were defined, with predictions of broadband applications usage in scenarios such as residential, business and industrial.

In MBS, cells will be confined to streets with dimensions of the order of a few hundreds of metres. The high mobility associated with it yields a tele-traffic analysis, where both new and handover connections traffic must be considered simultaneously. Research on traffic from mobility is available in [14], [15].

In packet switched networks the available resources are shared in a way that allows multiplexing of different traffic sources. As far as different sources do not take these peak values simultaneously, for a fixed number of users, the network can use less resources than would be required if resources were assigned according to their peak amounts required by each user, and a gain exists from this statistical multiplexing [16]. The identification of relevant models for the characterisation of voice, data and video traffic sources is needed, in view of finding a unified model to evaluate the QoS (Quality of Service), which depends on the aggregate traffic. Hence, keeping in mind that these models are needed for MBS cellular planning and optimisation purposes, the implementation feasibility of the aggregate traffic model is crucial in the choice of the basic model(s) for traffic sources. Results from research on multi-service traffic and system capacity determination can be found in [17], where the characterisation of services, applications, and scenarios is the one from [13]. As an analytical approach was sought, instead of a simulation one, the Bernoulli-Poisson-Pascal model was proposed for the computation of the blocking probability, and a user model had to be conceived to characterise the way an equivalent user of an application generates an actual service component user. From tables with results for the blocking probability (that generalise, in a way, the Erlang-B and Engset tables to multi-service traffic) it was possible to obtain the supported fraction of active users given the blocking/handover probability thresholds. While in the absence of mobility the average load of the mixture of applications is the most limiting factor, in the presence of mobility, the average velocity presents its limitation.

For the purpose of MBS optimisation, some useful cost/revenue models were developed, with an emphasis to MBS economic analysis incorporating multi-service [18]. A cost/revenue function was proposed, and some strategies were conceived for system deployment, in terms of the choice of the cell coverage distance, both in an initial phase of system deployment, when fewer users are foreseen, and in a medium term scenario, when more users have to be supported.

MBS Millimetrewave Trial Platform

Although OFDM may be a solution for the MBS radio interface, the approach from RACE-MBS (Mobile Broadband System) and ACTS-SAMBA (System for Advanced Mobile Broadband Applications) European Commission projects [19] was to assume TDMA/FDMA (Time / Frequency Division Multiple Access).

The SAMBA trial architecture was defined based on the state-of-the-art knowledge available when the specifications were frozen to start the design and manufacturing processes. The mission was to build an MBS demonstrator where the main functionality would be tested and evaluated. Since handover was seen as a key feature, the Trial Platform is composed of two Base Station Transceivers (BST) and one Base Station Controller (BSC) that interconnects to the fixed network. The architecture is shown in Fig. 6. Fig. 7 shows some pictures of the demonstrator (BST and Mobile Terminal). To facilitate the system's initial deployment the 40 GHz band was preferred instead of the 60 GHz [20].

This mini mobile system with two cells enables testing of many basic features, e.g., reliable transmission of information through the radio interface in a mobile radio environment (suffering from noise, co-channel and multipath interference), and also multiple access, dynamic resource allocation and mobility management, including seamless handover. It is, however, difficult to perform detailed studies of the impact of co-channel interference, and of the evaluation of more complex mobility management schemes. The availability of two MTs makes it possible to test the sharing, and dynamic assignment of bandwidth in a cell. This is an important feature due to the nature of broadband applications, which require asymmetry and variable transmission rate capabilities.

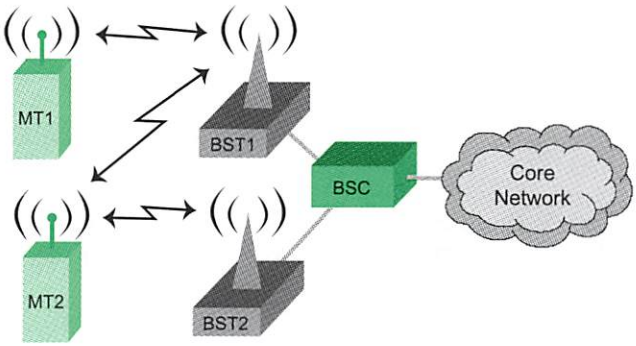

Figure 6. *SAMBA Trial Platform.*

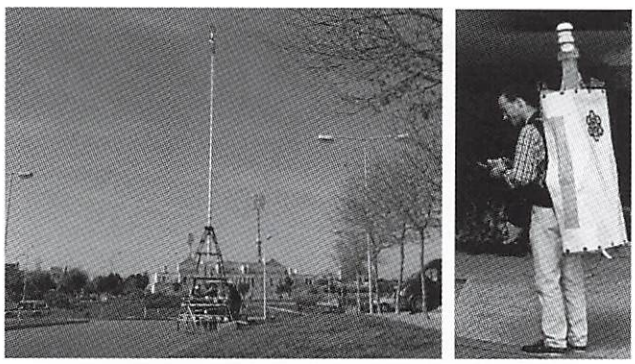

Figure 7. *ACTS-SAMBA Base Station tower and MT operation.*

Moreover, in order to increase capacity, for each MT, and for a particular instance, only the necessary bandwidth should be reserved. Full-duplex bearer services up to 34 Mb/s and a maximum mobile speed of 50-60 km/h were demonstrated in the SAMBA tests. Extensive Field Trials were carried out in the city of Aveiro, Portugal, and in different environments [5].

Air Interface and Cell Coverage

The air interface should provide the necessary resources and functions for the transparent transfer of information with the required quality of service concerning information loss and error rates, as well as delay. Several implementation constraints have been taken into account when designing the physical transmission scheme for the Trial Platform, namely:

- Propagation constraints of the millimetre wavebands.
- Power amplification constraints.
- Adoption of single carrier modulation with equalisation.
- Omnidirectional MT antenna (low gain).

The system is based on a single carrier modulation technique, and a hybrid TDMA/FDMA scheme (Time/ Frequency Division Multiple Access). It uses the Frequency Division Duplexing (FDD) mode to allow simultaneous transmission and reception on up- and downlinks [21]. The adopted access/duplexing scheme supports a gross symbol rate of 32 MBd full duplex (64 Mbit/s). For the Trial Platform only two carriers are required per cell (for up- and downlinks). The two have a separation of 160 MHz to avoid the adjacent channel interference, they being respectively: 39.58 and 39.74 GHz for uplink, and 42.58 and 42.74 GHz for downlink, Table 1.

Air Interface Parameters	Characteristics
Transmitted power	Approximately 20 dBm (100 mW)
Carrier frequencies	Uplink: 39.58 and 39.74 GHz Downlink: 42.58 and 42.74 GHz
Multiple access technique	FDMA/TDMA
Duplexing	FDD
Modulation & symbol rate	OQPSK at 32 Mbaud
Diversity	Two branch space diversity with "quasi-MRC (maximum ratio combining)"
Equalisation	DFSE – type Viterbi, 8 sy mbols (250 ns delay window)
Forward Error Correction (FEC)	(130, 110) Reed-Solomon code, 8-bit symbols
Frame	80 time slots (1.7125 ms)
Time slot	Duration of 21.406 μs. See [5] for details on the burst fields.

Table 1. *Air interface parameters.*

Since the power amplifiers used in the Trial Platform are strongly non-linear, an OQPSK-type modulation (Offset Quadrature Phase Shift Keying) scheme was selected. OQPSK is known to be well-suited to radio applications where saturated power amplifiers are employed since it provides a constant envelope or, at least, a low envelope fluctuation, a compact spectrum and a high detection efficiency obtained with simple low-cost receivers. The structure of the air interface frame and burst is explained in [5].

The shape of the cell was designed to cover the most likely general type of scenarios such as streets, large squares and large indoor arenas. The selection of lens type antenna technology, Fig. 8, allows for the easy design of the cell shape and a fairly uniform power flux density in the cell coverage area [22].

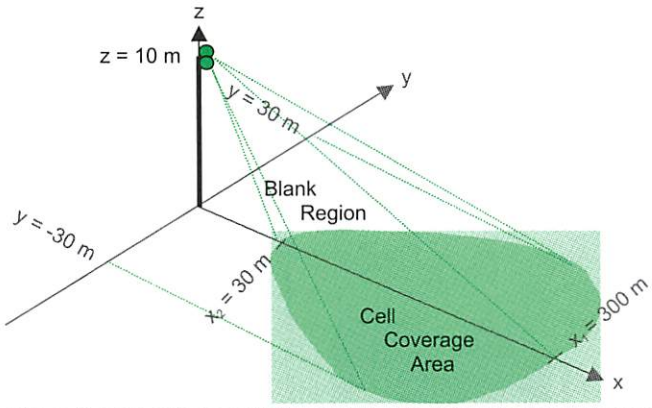

Figure 8. *Lens antenna radiation patterns and BS cells coverage area*

Moreover, the delay spread is maintained at acceptable levels by shaping the radiation pattern to avoid the transmission of the power to zones of no interest and potentiating the appearance of strong multipath reflections and therefore having a direct impact in the equaliser complexity. Given these facts, it is evident that the configuration of the cell (size and location of BS) is of primary importance for the global system performance. The change of the BS antenna height and tilting angle can be used to modify the coverage area. This allows a simple mean of controlling the illumination of sidewalls near the edges to minimise the channel impairments [23].

Fig. 8 shows the dimensions of the coverage area based on the signal strength. Dielectric type lens antennas with a sec2(q) radiation pattern were selected for the BS to compensate for the free space attenuation [24]. The MT antenna is omnidirectional to provide unrestricted mobility.

Field Trial Measurements

The main objective of the field trials was to evaluate the performance of the Trial platform in real scenarios at the 40 GHz band [5], considered to be as representative as possible of those in which MBS will operate, in order to anticipate the behaviour of the future MBS cellular segment. This was performed in a variety of outdoor and indoor scenarios. Moreover, to facilitate the measurement procedures the MT was installed on a trolley or in a van, for indoor and outdoor operation, respectively. Velocities up to 60 km/h were reached.

The aspects that can be evaluated range from the used baseband and RF technology, radio channel propagation behaviour, and air interface structure flexibility, up to the higher layer protocols. In each scenario, the MT moved along different paths, collecting enough measurements data to characterise the cell coverage in terms of power level and the system performance throughout the cell, namely BER (Bit Error Rate) at the output of the equaliser and before forward error correction, and the received signal power. These signals were collected by the BSC separately, with each data stream coming down from the corresponding BST. All measurement details concerning the conditions and configuration setup such as weather, BST location, antenna height, antenna orientation, MT path, scenario description, etc., were also registered for follow-up analysis.

A typical urban street in a residential area with a width of 36 m was selected for the outdoor measurements, Fig. 9. The outdoor measurements were performed with the MT antenna on the top of a van with the antenna fixed to 2.5 m. The BS was located near the central part of the street shown in Fig. 9, at different heights and pointing towards the end of the street, i.e., parallel to the buildings that exist on both sides. For the particular results presented here, the height of the BS was at 11.3 m. Results were obtained for several paths.

Fig. 10, on the left, depicts the received power in both channels (Ch. 1 and Ch. 2), and the combination of both channels using the MRC (maximum ratio combining) technique as a function of the distance between the BS and MT measured along the x-axis at a constant speed of 10 km/h. The MRC power level is also depicted together with the BER, calculated as an average value per frame, on the right. As shown in Fig. 4, the cell has a blank zone nearby the BS up to the 30 m distance. Beyond this point and up to the 50 m, the signal suffers variations caused by the BS and MT antennas radiation pattern fluctuations (see Fig. 5 of [15]). The average received power level dynamic range on the first 150 m is rather low due to the shaped radiation pattern of the BS antenna, and the small-scale fading depth increases significantly for distances above 100 m as the MT moves away from the BS with a visible improvement when diversity is employed.

Analysing the signal level variations along the path we can verify that during the first part (up to approximately 100 m) the variations are fast and of small amplitude, in contrast with the second part, where they are slower and deeper. This behaviour can be explained by the fact that in the first part the LoS component dominates, imposing the average level of the signal.

For the second part, the two rays model is a good approximation since, in this case, there is a clear dominant effect of the direct and ground reflected rays, although other multipath components are superimposed creating the low-level signal fluctuation.

Figure 9. *Outdoor scenario*

In Fig. 10 two deep fades are shown. After the first deep shadow fade due to an obstacle (e.g. small truck) the BER recovers quite well because the power level is significantly high (the system noise floor is about -92 dBm). However, after the second deep fade, the system was not able to recover. The Figure also shows that the BER rises with the increase of the small-scale fading depth, and also with the decrease of the average power level. However, even when the average power level is high enough (distances below 100 m), the BER sometimes is slightly above 10-3 due to the fact that in this zone the channel time dispersion tends to be higher.

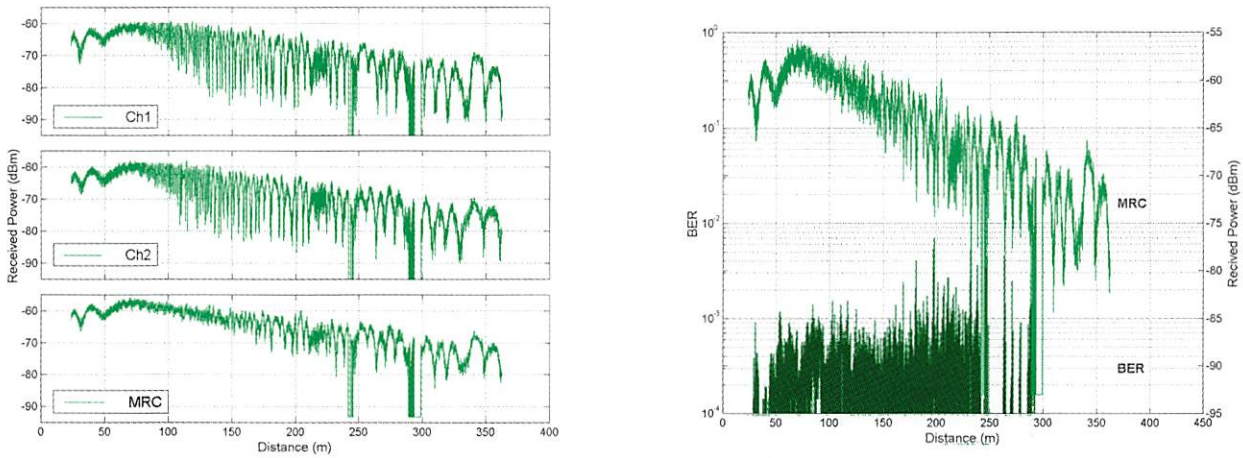

***Figure 10**. Received power and BER as a function of distance in a street.*

From radio interface measurement results performed in this outdoor canyon type street, and one indoor sports pavilion, it can be concluded that the average power level is approximately uniform for distances up to 150 m, as long as there is no antenna tilting, especially in the BS antenna, due to the lens antenna shaped radiation pattern. The wide cell size length was proved to be on the range of about 300 metres. However, for distances beyond 150 m, there was no compensation for the free space losses by the BS antenna. The Rician propagation models proved to fit well to the selected MBS outdoor scenario. Diversity has definitively contributed to the improvement of the received signal quality mainly under high fading depth. Analysing the BER figures it can be concluded that the selected equaliser is good enough, in general, for operating on the selected environments.

The system has proved to work with speeds up to 60 km/h but the maximum value was not reached due to safety reasons. Analysing the characteristics of the received signals when the speed changes, no significant impact on the average power level was detected although the LCR (Level Crossing Rate) and AFD (Average Fade Distortion) presented different, but expected, behaviours.

Conclusions

Given the large demand foreseen for mobile multimedia services and applications, MBS will certainly be necessary in the future, supporting high data rate applications, and to support very high traffic densities per square kilometre at low cost. R&D activities were presented, focusing on activities undertaken at the European level. The MBS concept was introduced to provide an overview of expected MBS features.

Aspects of cellular planning were discussed from the point view of cell coverage and large-scale frequency reuse, and a comparison between the 40 and 60 GHz bands was performed, by considering a simple model for the average received power, and analysing the carrier-to-interference ratio in different conditions. The characterisation of services and applications, deployment scenarios, and aspects of mobility have a strong impact on multi-service traffic which, in turn, in conjunction with the cell coverage and frequency reuse, yield inputs to a cost-revenue function that allows for MBS optimisation.

The main characteristics of the developed ACTS-SAMBA Trial Platform operating at the 40 GHz band were identified, covering system design and mitigation techniques, the shape and dimensions of the cells, and the main air interface characteristics. Different system configurations were trailed to investigate the effect of the antennas tilting both BS and MT. The results reflect the characteristics of the antennas radiation patterns. The two-ray propagation model was found to represent the behaviour of the radio channel for distances far from the BS. The main results obtained in the SAMBA project have shown that enough cell coverage area can be provided in the millimetrewave bands for MBS, although LoS may be required.

The utilization of a single-carrier modulation technique has proven to be a possibility to consider for the provision of a high transmission bit rate over the air interface. The equalization scheme proposed was able to handle the multipath delay spread in the environments selected for the tests. The handover of a 34 Mb/s full duplex radio link between two cells was also demonstrated. More recent measurements at the 60 GHz band can be found in [25].

MBS research activities are continuing at various levels, and in various locations. This will help in the definition and specification of beyond 4G mobile communication systems, noting that one of the main characteristics will be the availability of large transmission bandwidths and capacity per unit area and high mobility in a full converged scenario. The trend towards pervasive device interconnection highlights the need for network addresses space, which may justify the adoption of IPv6 technology in the near future.

Acknowledgements

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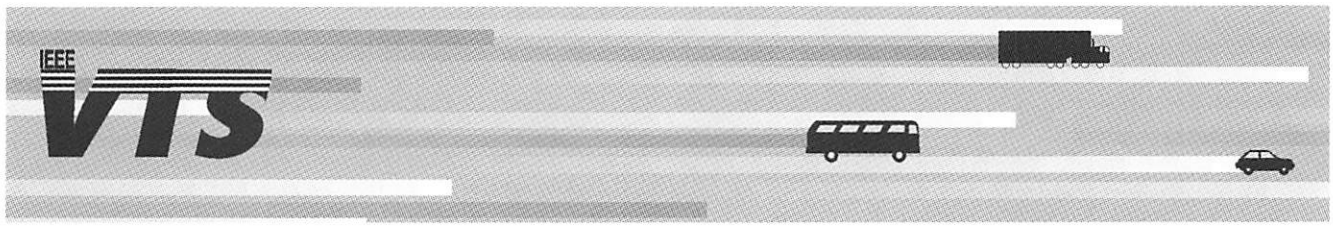

Automotive Electronics—What Makes it So Special?

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Automotive electronics consists of advanced sensors, control units, and "mechatronic" actuators forming increasingly complex, networked vehicle systems. The article shows typical requirements for automotive electronic systems and their components. While quantities are typically lower than in mainstream (consumer/telecommunication/computer) electronics applications, requirements regarding safety (flawless design), reliability and durability, operating conditions and temperature cycles, as well as long-term supply capability are much higher. As a consequence, automotive electronics is typically using well-proven technologies derived from mainstream electronics with some time delay regarding their introduction. In addition, automotive specific technologies have been developed for highly integrated control units and "mechatronic" actuators. Some recent examples are given. The paper closes with a vision regarding further developments and trends in Automotive Electronics.

Introduction

In recent years, modern vehicles are showing an increasing number of electronic systems and functions. The driving forces behind this development are the ever growing needs for more safety, less emissions and energy consumption, more driver information and driver assistance, and last but not least more driving fun and comfort.

The history of modern automotive electronics started in the 50's to 60's of the last century with the introduction of semiconductor transistors in car radios and power diodes in alternators. Since the 80's, the integration of electronic systems like engine management or brake control systems has come into focus. The era of today is characterized by the vehicle-wide networking of all electronic vehicle systems, thus allowing for new additional functions. As a next wave, we expect an increasing networking between the vehicle and its environment. All those trends are enabled by electronics and communication technologies supporting increasing digitalization, integration and networking of electronic devices.

Towards the Intelligent Vehicle—Challenges and Requirements

In our vision, the "intelligent" vehicle of the future will consist of three mayor architectural elements:

- "intelligent" sensors
- powerful electronic control units
- "mechatronic" actuators

Thus, all vehicle functions will be controlled using networked electronic sensors, control units, and "mechatronic" actuators.

As a consequence, automotive electronics is expected to continue its growth - by about 6% p.a. regarding the overall systems value, or even 10% p.a. regarding the specific semiconductor content.

However, this growth will only continue if we cope with some severe challenges:

- How to handle the increasing complexity of networked automotive systems in the development phase?
- How to keep vehicles – despite their increasing electronics content – affordable for the consumer?
- How to assure extended lifetime reliability and availability of the vehicles despite the underlying, very complex electronic systems?
- How to cope with the necessity to supply the aftermarket with affordable electronic components

Naturally, there is not one single answer to those challenges, but a plurality of solutions is required to fulfill the requirements.

The Importance of Architectures, Interfaces and Standards

In this paper, we highlight primarily the perspective of automotive electronics hardware. Obviously, other aspects of automotive electronic systems are as well of great importance for the overall performance and will certainly affect hardware. Some of those aspects are listed here:

Systems Architecture: the further development of automotive electronics will be strongly influenced by underlying

decisions on the vehicle's overall systems architecture, covering the distribution of functions to subsystems, their partitioning, and their mutual networking/communications infrastructure. Our perspective on systems architecture consists of functions being well structured according to CARTRONIC [1] principles, resulting in a clearly structured domain architecture. We expect further concentration of functions within those domains using a smaller number of separate ECU's (becoming "domain controllers") and a growing number of intelligent sensors and intelligent actuators.

Standardized Interfaces: while today's interfaces between electronic subsystems are mostly proprietary and even application-specific, we expect increasing standardization in this area, allowing better exploitation of economics of scale, and a reduction in application specific adaptation and debugging work.

Parameter	Consumer	Industrial	Automotive
Temperature range	0°C to 40°C	-10°C to 70°C	-40°C to 85/155° C
Operation time	1-3 years	5-10 years	up to 15 years
Humidity	low	environment	0% up to 100%
Tolerated field failure rates	< 10 %	<< 1 %	target: zero failure
Documentation	none	conditional	true
Supply	none	up to 5 years	up to 30 years

Table 1. *Requirements on electronic devices*

Bus systems for networking: As new vehicle functions will mostly depend on the combination of several subsystems (sensors, actuators) within different vehicle domains, the amount of subsystems networking will certainly increase further. While the high-speed and lowspeed CAN will remain the predominant networking bus standard for the next years, increasing bandwidth requirements and the need for a predictable, deterministic behavior will motivate innovative, high-end system applications to use FLEXRAY [2] as their main "backbone" solution, interconnecting the electronics of mission-critical domains (powertrain, chassis, occupant safety, driver assistance). For other applications (mobile communication etc.) dedicated bus solutions will continue to be used.

Software Architecture: in parallel to the creation of domain-oriented systems architecture with standardized interfaces and new bus systems, also the software architecture within the ECUs will be further modularized and standardized in order to allow re-use of software investments and more flexible software distribution between various ECUs.

In our view, today's mainstream for the new systems architecture, interface standardization and new software architecture is formed by the AUTOSAR initiative [3]. Similarly, we consider FLEXRAY [2] to become the future mainstream for high-end networking busses.

Reliable electrical supply systems: Regarding the overall performance of "mechatronic" systems, the efficiency, reliability and availability of the underlying electric power supply is of core importance. New power semiconductors allow developments like integrated electronic battery monitoring, electrical energy management [4] integrated electronic power steering systems for midsize cars and highly efficient starter-generators.

Mature product development processes: last but not least, both software and hardware for up-to-date automotive electronic solutions must be developed using systematic, mature, integrated product creation processes. The organization of V-shaped simultaneous-engineering processes for all product aspects (from overall system to individual components, both hardware and software) according to CMMI [5] requirements is considered to be key for the quality and efficiency of the results.

Requirements for Automotive Electronics Hardware

Let us now turn our focus on automotive electronics hardware. To start, Table 1 shows a comparison of some requirement profiles for electronics in consumer, industrial, and automotive applications.

It is easily seen that automotive electronics is subject to much higher requirements and specifications than other "mainstream" applications. In the following, some specifics are highlighted:

Environmental and Operating Conditions

The requirements regarding environmental and operating conditions of automotive electronics are typically characterized by at least three elements,

- operating temperature range (minimum and maximum temperatures)
- number of temperature cycles over lifetime in the Application
- the peak mechanical accelerations.

The following Figure 1 shows some typical values for environmental temperatures and peak mechanical accelerations:

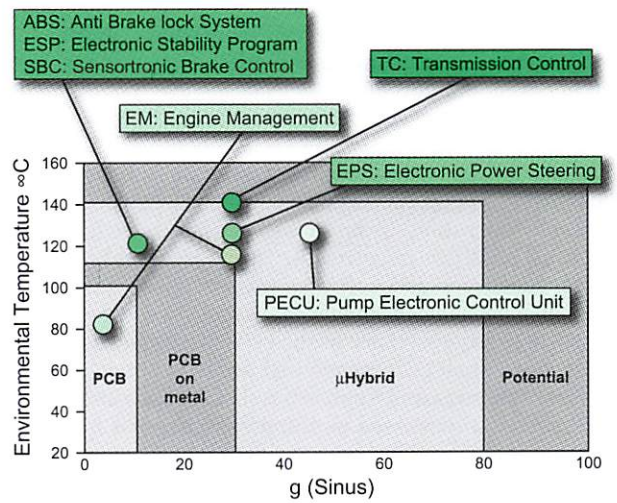

Figure 1. *Environmental temperature and peak accelerations for automotive electronic control units*

In addition, protection against climatic influences (humidity), high-pressure cleaning or corrosive substances (salt, fluids, vapors etc.) over lifetime are required depending on the application.

While the values shown above give the current status of requirements, we must note that throughout the last years the automotive requirements have been continuously increasing. This is related to several facts, for example

- rising underhood temperatures as a consequence of higher engine output, drag optimized hood shapes, and noise encapsulation of engines,
- rising power dissipation of microcontrollers due to increased clock frequencies,
- rising electrical power demands of control unit loads (like valves, motors etc.),
- higher integration of automotive electronics (more power in smaller packages), both on the level of semiconductors and control units

- the trend to apply more sensors and "mechatronic" actuators directly in environmentally difficult locations (on-engine, in-exhaust, within transmission, on-wheel, on-axle, in-tire,..).

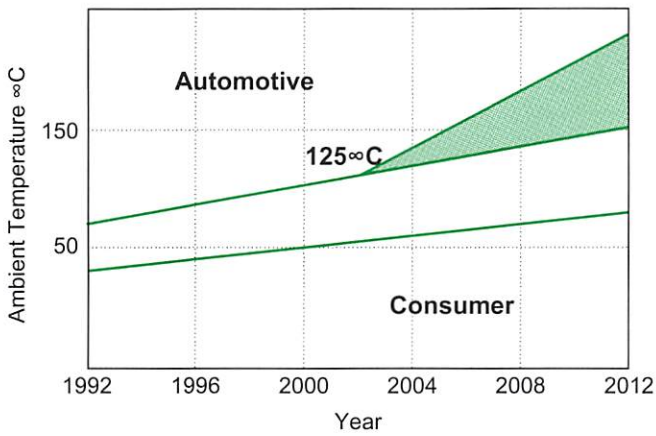

Figure 2. *Increasing temperature requirements over time*

As an example, Figure 2 shows a comparison between automotive peak operating temperature requirements versus their consumer electronics counterparts:

Reliability and Safety

Obviously, as the vehicle operation depends almost completely on the functionality and availability of its electronic systems, and as many of those systems are also related to the safety of the vehicle passengers, extremely high requirements regarding the reliability and safety of Automotive Electronics Hardware must be fulfilled.

Regarding safety, the basic general requirement is at least a "fail safe" operation – even in case of a failure no harmful or dangerous condition must result. This is assured by a proper system, hardware and software designs based on detailed FMEA analysis. Depending on the results and the classification of the safety-relevance of the system, elaborate monitoring functions must be implemented to detect potentially safety-relevant failures and apply suitable fallback strategies [6].

Reliability is expressed as the probability of a failure per electronic device (at 0 km or in the field over a given period of time). Reliability requirements have been continuously rising, and we may expect that trend to continue further throughout the next years: the more electronic devices are used in a vehicle, the higher is the demand for their reliability and availability. While the reliability of individual components and ECUs has been continuously improved over the last years, the trend is somewhat offset by the increased number, performance and complexity of devices, as it is shown in Figure 3.

As a result of the increased use of automotive electronics in modern vehicles, car manufacturers are today asking for ECU 0 km and field failure rates < 10 ppm. The consequence of this requirement on the electronic components is discussed in the next section.

Electronic Components for Automotive Applications

In order to achieve a 10 ppm requirement for ECUs, we may derive suitable limits for all potential failures and defects. Figure 4 shows an exemplary brake-down scheme for 0-km failures.

As a result of a detailed analysis using real data, it may be concluded that the allowable limits for automotive elec-

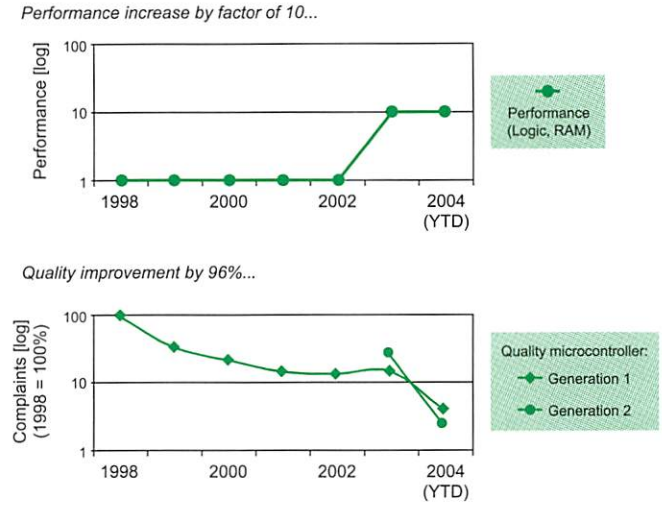

Figure 3. *Example: reliability improvement of 2 generations of comparable microcontrollers 1998-2004*

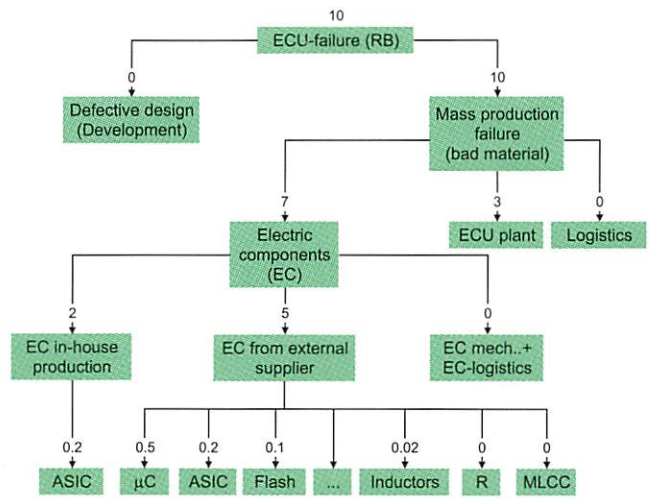

Figure 4. *Breakdown of ECU ppm reliability requirements (example)*

tronic component failures must be significantly below 1 ppm, which is in fact equivalent to a zero-defect target for typical quantities.

Depending on the complexity of the component, individual maximum allowable failure rates have been assigned to all components. As a result, it is seen that many components are already today fulfilling such sub 1-ppm requirements, but that the reliability of complex semiconductor components must be significantly improved: for example, for 32bit microcontrollers typically by a factor of 30, compared with today.

As typical consumer or industrial semiconductors do not fulfil such sub-1-ppm reliability requirements, specific solutions regarding design, manufacturing and testing of complex automotive semiconductor components are urgently needed in the semiconductor industry.

A Technology Comparison Between Consumer and Automotive Electronics

The increasing requirements of Automotive Electronics regarding environmental/operating conditions and reliability/safety shown in the previous paragraphs have three consequences:

1 Automotive electronics is mostly based on "mainstream" (consumer/industrial-dominated) technologies in order to save investments and make use of volume synergies,

2 But it is following the mainstream with a delay of several years, time which is needed to make new electronics technologies "automotive compliant" and learn how to use them under automotive conditions.

3 For high-end requirements – where mainstream electronics do not offer any suitable solutions that may become "automotive compliant" –automotive electronics has been forced to develop its specific own solutions.

Some examples for thesis 1 and 2 are given in the following statements:

Processor clock frequencies are significantly lower in automotive applications compared with consumer applications, see Figure 5. Reasons are (among others) the high EMC requirements combined with extended operating temperatures and limited processor cooling options in vehicles.

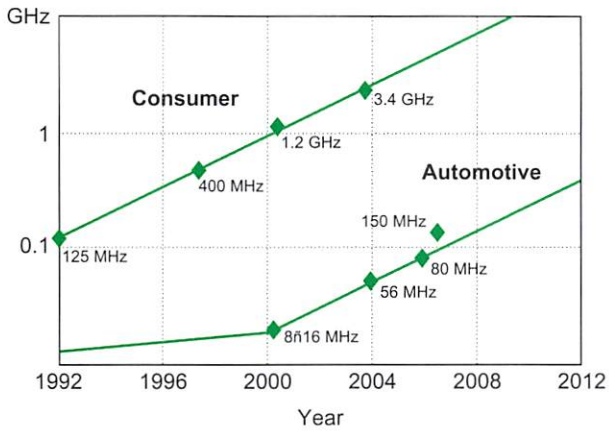

Figure 5. *Development of processor clock frequencies in consumer vs. automotive electronics*

Semiconductor structures are significantly smaller in consumer applications, resulting for example in an increased number of transistors per processor chip compared with automotive applications, Fig. 6:

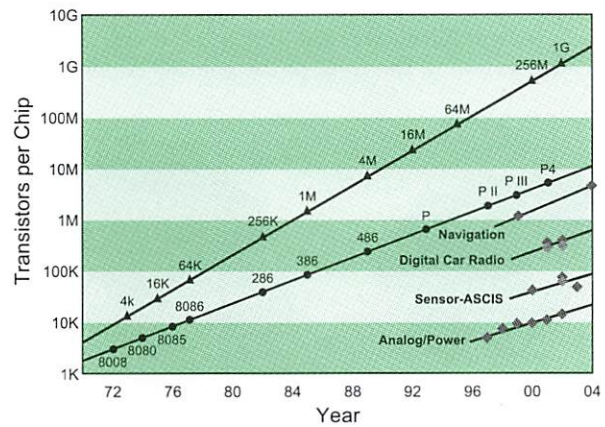

Figure 6. *Development of processor complexity in consumer- vs. automotive applications*

It may be observed that automotive semiconductors are typically about two technology generations behind consumer electronics. New semiconductor technologies are always first introduced in mainstream areas. Only after having gained sufficient experience with new manufacturing processes, it is possible to fulfill automotive quality requirements. Also, the harsh vehicle electrical environment (EMC, ESD requirements) has offered always some initial hurdles for advanced semiconductor processes.

As the internal structure of automotive semiconductors is less complicated than in advanced consumer electronics, pincounts of components may be also significantly smaller than in consumer applications. This corresponds also with a delayed introduction of advanced semiconductor packages in automotive technologies (Fig. 7).

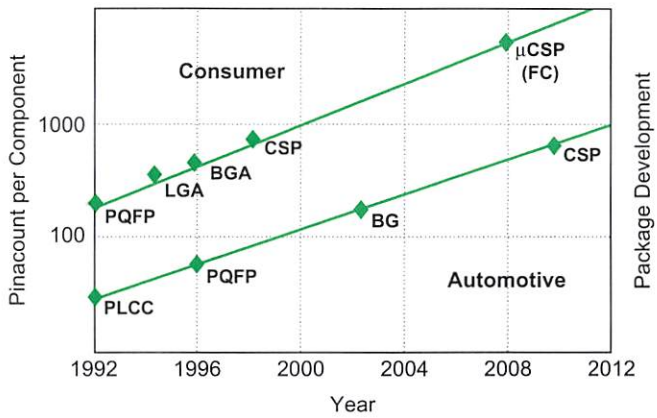

Figure 7. *Development of IC pinacounts and packages in consumer vs. automotive electronics*

As a consequence of the aforementioned points, also printed circuit technology for automotive applications is following consumer electronics with some delay (Fig. 8). The structure width is typically higher in automotive electronics, and the number of PC board layers is smaller in automotive electronics (today typically up to 8 in automotive vs. up to 32 in consumer electronics).

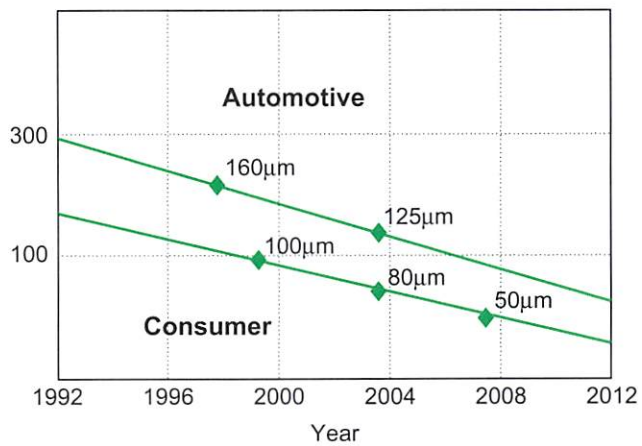

Figure 8. *Development of printed circuit structure width in consumer vs. automotive electronics*

Considering those examples, one might discuss whether automotive electronics are too conservative or too slow in its developments. Newer technologies typically bring substantial cost and packaging benefits. However, we must acknowledge that those automotive technology solutions introduced with some "delay" are not identical with their corresponding mainstream technology counterparts, but have undergone substantial work regarding their detailed design, application and manufacturing processes in order to make them suitable for mission-critical automotive applications. Also, accepting extended risks when introducing not so mature technologies might lead to very high quality costs, easily surpassing the anticipated savings. – It is our understanding that safety, reliability and quality are always of

first priority in any automotive application. Therefore, using only proven technologies in automotive electronics is always mandatory.

Automotive Specific Electronic Technologies

Let us give now one example for an automotive-specific technology (according to the last paragraph's thesis 3). For high-end applications with very tough requirements, Bosch together with its partner Ogaki Ceramics (today part of Murata Corp.), have developed a specific LTCC (low-temperature cofire ceramics) multilayer technology [7], which in its present stage is able to support temperatures above 140°C and peak accelerations of more than 80g, see also Fig. 1. The development has been specifically directed towards automotive applications, as LTCC applications in consumer electronics are mostly specialized for high-frequency applications.

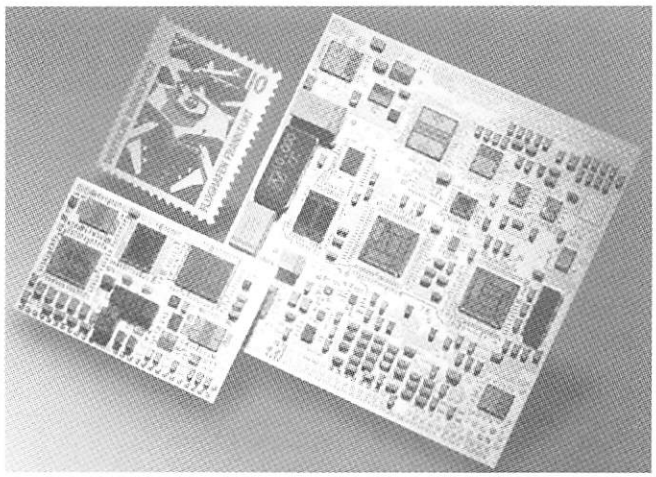

Figure 9. *Multi-layer ceramic substrate examples (postal stamp for size comparison)*

Bosch's LTCC "micro hybrid" circuits, Fig. 9, consist of four to six layers of ceramics, having 0.6 ... 0.9 mm thickness, being sintered at 900° C. Each layer contains a part of the wiring circuit layout, the layers are interconnected by means of conductive vias. Additional "thermal vias" support heat dissipation from the front to the rear side. Integrated circuits are mounted as "bare die" (unpackaged) directly to the micro hybrid, connected via 25µm or 32 µm gold wire bonds. At the rear side, printed resistors are located; they may be laser trimmed down to 0.5% tolerance. Currently the technology supports a conductor and via size of down to 130 µm, ongoing developments will achieve further miniaturization. It should be noted that the LTCC technology is completely lead-free.

Summarizing, LTCC based micro hybrid circuits are extremely compact, much smaller than a printed circuit board, and supports a much tougher environmental condition. They are thus being ideally suited as core for "mechatronic" actuators. Since their introduction in 1995, more than 70 million units have been produced at Bosch's LTCC plants in Reutlingen/Germany and Anderson/South Carolina.

Some Recent Examples of Automotive Electronics Applications

1 Control Unit for Electrical Power Steering (EPS)

The second generation EPS control unit developed and manufactured by Bosch for ZF Lenksysteme electrical

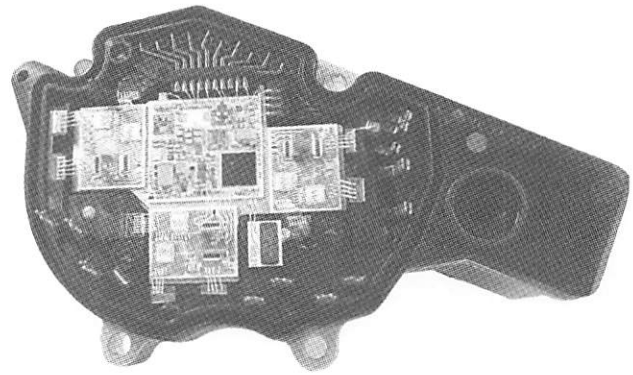

Figure 10. *Control unit for Electrical Power Steering (EPS) using LTCC micro-hybrid technology*

assisted power steering system [8] is a typical example of an intelligent actuator. The device was introduced in 2003 for large-volume production. The control unit is directly attached to the electrical steering servomotor thus forming a highly-integrated "servo-unit" which is directly mounted to the front axle. The ECU is using the latest LTCC- and DBC (Directly Bonded Copper) technology, thus allowing for high currents, high temperatures and high shock resistance within a very small, individually to the car design adapted, package. The small package counts heavily on large-scale integration of digital and analog peripheral functions into 2 specific ASICs developed and manufactured by Bosch.

2 Adaptive Cruise Control and Predictive Safety System

As an example for an "intelligent sensor", we would like to present the 2nd generation Adaptive Cruise Control (ACC) unit introduced by Bosch currently in the market. In today's industries' smallest (7.4 x 7.1 x 5.8 cm) housing for such a device, we package both the 77 GHz Radar transceiver as well the very powerful signal processing and vehicle control hardware. The unit's small size allows for easy application in the front of the vehicle. An electrically

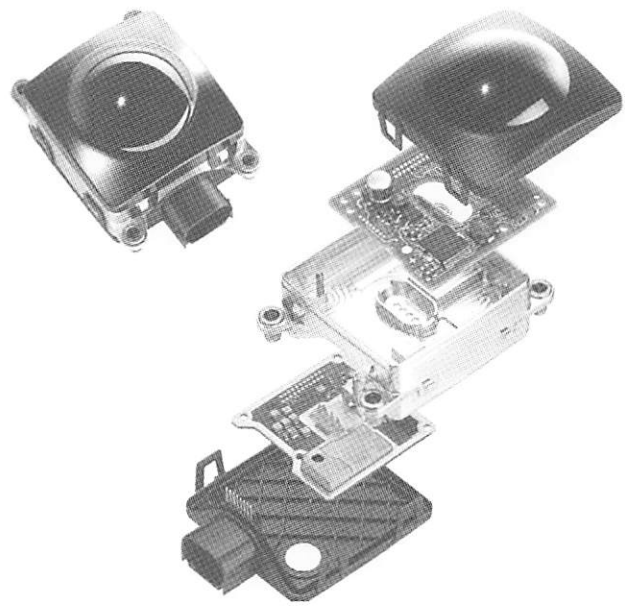

Figure 11. *Intelligent Sensor for Adaptive Cruise Control (ACC) and Predictive Safety Systems*

heatable front lens allows also operation under bad weather conditions. Despite the small size, the unit has computing performance that allows further functional expansion. From 2005 on, additional functionality will be integrated into the device: the cruise control capability is going to be expanded over the full speed range (down to zero), thus supporting also slow-speed stop and go traffic situations. The unit will additionally include "predictive safety system" functionality [9] for advance detection of potential emergency situations, allowing brake and restraint systems to optimize their response and give the driver additional warnings. – The small size and high performance of the device has been made possible by extensive high-integration of peripheral circuitry into few dedicated ASICs, custom developed by Bosch for this application.

3 Body Control Module

As a further example of today's Automotive Electronics we like to share some details about the Bosch Body Control Modules (BCM) family. These modules typically host a number of independent features, from safety to convenience, from power electronics to RF technology. Inputs are sensors, antennas and switches (Keypads). Outputs are High- and Low-side drivers, relay contacts and interfaces (CAN, LIN etc.) to other electronic modules in the car. Body Control modules can be integrated into the power distribution panel to create smart power distribution modules. This is in particular useful if load management is required to assure certain functionality even in a low battery condition. The complete functionality can be either build into one box or distributed into a number of interlinked modules to optimize size (packaging), weight and cost (wiring harness).

Conclusion and Outlook

Summarizing, automotive electronics has to deal with requirements that are substantially higher than in mainstream electronics. It has been shown that automotive electronics technologies typically follow the mainstream trend with some time delay, due to the requirements of using only proven, mature technologies for mission-critical applications.

We assume this trend will continue. However, considering the ongoing shrinking of mainstream electronics (using, for example, sub-90 nm semiconductor structures produced in 300mm wafers), some new challenges are seen on the horizon:

1 Automotive capability of future electronics technologies! It will be a considerable challenge to qualify and adapt such sensitive technologies to fulfill automotive requirements.
2 Affordability! As those technologies are usually based on heavy manufacturing investments and very high volumes—much higher than typical volumes in the Automotive industries—automotive specific solutions will become economically more difficult. Will automotive quantities be sufficient to justify specific semiconductor designs?
3 Speed of innovation! In case that automotive electronics must closer reflect "mainstream" technologies—how can we speed up their application without taking risks on quality and reliability?

Obviously, those challenges can be only met by substantial R&D investments under close cooperation of the vehicle manufacturers, their automotive electronic system suppliers, and the semiconductor industry. Regarding the specific and increasing requirements of automotive electronics, it is very likely that automotive electronics also in the future will continue to be "quite special" when compared to mainstream electronic applications.

Acknowledgments

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Automotive Electronics

Bill Fleming, Senior Editor

Automotive Electronics Technologies That Made Their Mark

Many technologies were cited in an automotive editorial [1] and ones involving automotive electronics are reviewed here. Although in some cases it may not be obvious, each one of the technologies described here are dependent on electronics for their operation. In the order given in [1], the technologies are as follows.

1. **Radio Services** — With roadside help, real-time traffic reports, diagnostics and satellite communications; the car radio heads into the 21st century with an extreme makeover, now including services such as OnStar, XM Satellite Radio, and Sirius Satellite Radio.
2. **Chassis Control Systems** — Anti-lock braking systems led to automatic traction control. Now "intelligent" chassis systems provide stability control for increasing numbers of premium cars, crossovers, and tall, tippy vans and SUVs by sensing under- and oversteer and applying judicious braking to keep them under control.
3. **All-Wheel Drive** — Although AWD was first offered 30 years ago, Subaru and Audi continued to develop it and AWD vehicle production today totals nearly a million units worldwide.
4. **Parallel Hybrid-Electric Powertrains** — Fuel-efficient gasoline or diesel engines are combined with an electric motor that not only serves a supercharger-like acceleration-boost function, but can be used to run the vehicle on electricity only, saving even more fuel. One industry analyst predicts that eventually all ICE-powered vehicles will be hybrids.
5. **Cylinder Deactivation** — The idea of deactivating cylinders to reduce fuel consumption is not new. However, thanks today to advancements in electronic technology, cylinder deactivation is making a comeback. For example, Chrysler's new 5.7L Hemi engine with cylinder deactivation on its MY2005 Chrysler 300C, Dodge Magnum and Jeep Grand Cherokee vehicles, provides up to a 10 percent improvement in fuel economy.
6. **Safety** — The past decade has seen the emergence of adaptive seatbelt and airbag systems designed to tailor their level of protection based on the crash severity and the size and position of the occupant at the time of impact. Impressive crash test performance for vehicles with side airbags have led to the introduction of standard equipment side-curtain airbags which protect the occupant's head and torso during a side-impact crash. Collision-avoidance systems, which sense an impending crash or rollover, work hand-in-hand with the advanced passive seatbelt and airbag systems.
7. **The New Diesel Engines** — It's impossible to launch a vehicle in Europe these days without offering a diesel engine option. The 40-percent penetration of diesel engines in Europe was driven by high fuels costs, but Europeans have also fallen in love with the diesel's new and improved driving dynamics.
8. **Lane Departure Warning** — Drowsy driving has long been a hazard, especially for long haul truckers with deadlines to meet. Iteris Inc. developed a system that warned sleepy or inattentive drivers that they were leaving their lane. A special camera, mounted ahead of the rearview mirror, "reads" the lane markers on the road and sends either audible or visual lane-departure warnings to the driver.
9. **CVT vs. Six-Speed Transmissions** — The search for better fuel economy today goes beyond the engine as automakers experiment with more fuel-efficient transmissions. Two promising transmission technologies, the Continuously Variable Transmission (CVT) and the multi-speed electronic transmission, will battle it out for supremacy. The 6-speed automatic transmission is fast becoming the norm, replacing 4- and 5-speed automatics on many cars. Initial tests show that while the performance and fuel efficiency of both CVT and 6-speed automatic are about the same, economics may be the differentiator. CVTs are more complicated and more expensive to build. Several manufacturers are now working together on cost-effective 6-speed transmissions.

Portable Electronics Threaten Embedded Electronics

Paul Hansen [2] suggests that, "The automotive electronics industry is wise to keep an eye on what's happening with portable electronics." While portable radios and portable cassette and CD players didn't end up hurting the market for factory-installed audio products, the portable cell phone has all but wiped out the market for embedded cell-phone handsets. Now other portable electronics — including navigation devices, satellite radios, digital media players and DVD players — are threatening the OE market for embedded electronics. Just as the market for embedded navigation devices may finally be moving into a growth stage with 3 percent penetration of new U.S. vehicles in 2003. and potentially climbing to 10 percent penetration by 2008; a number of promising portable navigation products have emerged that compete head on with embedded devices.

For example, Garmin Intl. recently introduced a pocket-sized portable car navigation device that retails for $599 — half the price new car buyers pay for factory-installed navigation. The device, which includes a 2.2 by 1.5-in. color display and voice directions, can be moved from car to car, or

brought along while navigating on foot. It is accurate to within three meters 95 percent of the time.

In another example, Motorola's Viamoto software turns portable cell phones into navigation devices.

Last year, Avis Rent A Car Systems began using Viamoto software installed in cell phones to provide voice-enabled directions to Avis customers. Rather than requiring each phone to carry large amounts of data and computing power, an up-to-date map data file is kept at the Avis Advisor call center, where a server creates the directions and downloads them to the phone.

A big advantage of portable navigation devices is that they can be used both inside and outside the vehicle.

In another portable application, Motorola, with its partner Giant Intl., is unveiling a palm-sized XM2GO XM Satellite Radio receiver. With a built-in antenna, the radio can be enjoyed at home, in the car, or on the go. Similarly, the world's first portable satellite receiver was introduced by Delphi — their XM SkyFi receiver, including car kit to access the car's audio system, is available from Wal-Mart for less than $120.

Competition for embedded products also comes from portable digital media players. The most successful of these is the iPod from Apple Computer. While some carmakers in Japan have begun factory installing hard-disc drives that handle both map data and music files, the enthusiasm for iPod will most certainly dampen the demand for embedded hard-disc drives to store music. Many iPod users will surely prefer to bring their iPods into the vehicle rather than going through the hassle of downloading music to the vehicle.

The best things about portable electronics are that they are usually more up-to-date, cost less, and can be used in and out of the car. On the other hand, embedded electronics have the advantages of larger displays, providing easier-to-find control knobs/switches, and generally a more robust design [2].

Nano-Particle Infrared-Absorbing Glass Layer

Solutia, a supplier of automotive glass products, introduced a new technology for the Citroën C4. The material called Vanceva, includes nano-particles, which improves solar infrared absorption [3]. This material is a new tool for controlling solar heat load. The Citroën C4 includes a Vanceva solar layer in its panoramic glass roof to provide benefits beyond those associated with other established solar-heat-control technologies such as tinted glass and coated glass.

Lanthanum-hexaboride nano-particles are semiconducting and exhibit strong absorption for solar near-infrared wavelengths when their particle sizes are in the nanometer size regime. The physical mechanism of IR absorption involves 'surface plasmon resonance,' an interaction of surface electrons affecting the optical behavior of the nano-particles. The nano-size of the particles also ensures that light is not scattered, thereby avoiding hazy viewing through the windows [3].

Factory-Installed Air Freshener

In addition to the infrared-absorbing glass (above), Citroen is also introducing a factory-installed air freshener in its new C4 model. Up to now, auto makers have tried to completely eliminate bad odors associated with plastics and glues, but Citroen "saw customers buying things like little pine trees for their mirror to give the inside of the car a good odor." A long-lasting (smell-retaining) wick material was found in the medical industry, and a vaccine manufacturer was discovered in Germany whose engineers were able to develop a machine that would put 0.04 oz. (1 g) of perfume in the wick, fill and assemble the cartridge, and package it [4].

Citroen originally asked suppliers for up to 25 different scents. In the end, only three scents were chosen: mint, musk and vanilla. A package of the three scents is placed in the glove box of each new car. Later, customers can buy refills at dealerships. Customers are able to switch between them instantly using a button on the console, and the scents diffuse through all HVAC vents.

Driver Distraction Studies — Update

According to NHTSA (National Highway Traffic Safety Administration — U.S.), each year 25% of the 6.3 million vehicle crashes, and 6.5% of all fatal crashes, involve some type of driver distraction. The Virginia Commonwealth Univ. researched 2,700 crash scenes, all involving distracted drivers, and a list of most frequent causes of distracted driving was determined [5]. The top ten ranking causes of driver distraction were:

16% – looking (gawking) at a crash, vehicle, roadside incident, or traffic
12% – fatigue (drowsiness)
10% – looking at scenery or landmarks (sightseeing)
9% – distracted by actions of a passenger or child
7% – adjusting radio, changing CD or tape
5% – talking on cell phone
4.5% – eyes not on the road (e.g., looking at a passenger while talking)
4% – not paying attention (daydreaming)
4% – eating or drinking (hot coffee is the worst [6])
4% – adjusting vehicle controls

Although many people think of cell phones as a major safety hazard, the above list shows that they only ranked sixth among the top ten causes of driver distraction-related crashes.

Moreover, as opposed to other factors, cell phones also save great numbers of lives via emergency calls made to expedite medical dispatch and treatment. Statistics show for example that, "an average of just 9 minutes earlier arrival of emergency help will annually save about 3,000 lives, about the same number of lives as are saved annually by air bag protection" [7].

NHTSA's latest cell phone use survey, conducted as part of the annual NOPUS (National Occupant Protection Use Survey) study, was conducted last summer at 1,200 scientifically selected road sites across the country. The survey found that more motorists than ever use cell phones while they drive [8]. In 2004, at any given daylight moment, an estimated 8 percent of all motorists in the U.S., or about 1.2 million drivers, were using cellular phones (both hand-held and hands-free) while operating their vehicles. The survey estimated that 5 percent of motorists in 2004, or about 800,000 drivers, used hand-held cellular phones, and 3 percent used hands-free types.

It was found that motorists are more likely to use phones when driving alone. Six percent of drivers traveling alone were holding cellular phones, compared to 2 percent of cell phone-using drivers who had at least one passenger. It was also observed that drivers who had at least one child passenger (7 years old or younger) were equally likely to use a hand-held cell phone as were drivers with no children on board [8].

Automotive Radio Expanding Technologies

Here are frequency allocations for U.S. current-production automotive radio technologies [9]:

- 530-to-1700 kHz, for the longstanding AM radio broadcasting
- 26.965-to-27.405 MHz, forty channels, for Citizen's Band CB use
- 88-to-108 MHz, for FM radio broadcasting
- 825-to-895, 901-to-941, and 1850-to-1990 MHz; for cell phone operation
- 1575.42 MHz, for GPS navigation operation
- 2320.0-to-2332.5 MHz, for Sirius Satellite broadcasting
- 2332.5-to-2345.0 MHz, for XM Satellite broadcasting

Then there are new frequency allocations for the following future automotive radio technologies that are now under development [10].

- 0.1-to-30 MHz shortwave, digital-AM, DRM (Digital Radio Mondiale —Europe/U.S.), which will be decoded by software-defined multi-format (future) digital radios
- Existing AM and FM broadcast frequencies, to be upgraded with DAB (Digital Audio Broadcast) that more efficiently utilizes frequency spectrum and provides sound quality superior to that of prior analog broadcasts. DAB will also be decoded by software-defined (future) digital radio receivers.
- HD (High Definition) radio is another upgrade to existing AM and FM broadcast frequencies, and it will also be decoded by software-defined (future) digital radio receivers.
- 2.4-to-5.0 GHz discrete frequencies, for Wi-Fi (Wireless-Fidelity), offer low-power, medium-range (20-to-300 m) communications between home and vehicle (for downloading files, including music), paying tolls, parking, etc. [11].
- 2.402-to-2.480 GHz frequencies, with 1-MHz frequency-hopping — are utilized by Bluetooth, a wireless low-power near-range (10-m max) technology, primarily used inside of vehicles [11].

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Mobile Radio

Javier Gozalvez, Senior Editor

Technology and Research News

Siemens has announced the availability of new GPRS radio modules for machine-to-machine (M2M) communication. The new functions include a world-first in the form of the Java-based and quadband-capable TC65 module, which can be used in all GSM networks. The Java Open Software-Platform makes it possible to control the customer application with components integrated on the module, such as a processor or memory. A further module is the TC63 which is intended primarily for integration into simple M2M applications, such as vending machines. Orange and Siemens haven also announced a new partnership to develop and market vertical sector M2M solutions for mobile communication across Europe. Siemens will be providing its wireless module TC45 for the Orange M2M Connect software platform. According to the companies, M2M Connect from Orange is the first and only combined network and data platform on which vertical applications for M2M solutions can be supported.

Nokia has introduced a new product for secure mobile contactless payments and ticketing. What the company claims is the world's first Near Field Communications (NFC) product for payment and ticketing will be an enhanced version of the already announced Nokia NFC shell for Nokia 3220 phone. Nokia has also announced it will incorporate a single chip solution based on Texas Instrument's Digital RF Processor

NTT DoCoMo's N506iS phone

(DRP) technology to its future mobile phones. The cooperation will allow Nokia to offer more cost-effective advanced handsets, especially in high-volume entry markets. As a first step, Nokia phones based on the single-chip solution will target the entry-level mobile phone market, particularly in high-growth regions such as India and China.

NTT DoCoMo has launched the 2G mova N506iS mobile phone, which the company claims is the world's first phone to contain a flat panel display that also functions as a speaker. The flat panel speaker emits sound by sending vibrations throughout the entire display panel. The user can hear the person on the other end by placing an ear anywhere on the panel. In addition, the speaker's use of the entire display makes audiovisual content more vivid than conventional handsets.

Andrew Corporation has introduced the Decibel dBMicro-VTree three-sector antenna system, one of the industry's smallest cellular and PCS network solutions for sites where real estate is limited or antenna concealment desired. The dBMicro-VTree features three independent cross polarization antennas in a single, slender unit with no visible cables that can be mounted on locations such as rooftops, monopoles, and billboards. The dBMicro-VTree is concealed in a slender 165.1 millimeter radome for 1850-1990 MHz and 1920-2170 MHz and an 11 inch (279.4 millimeter) radome for 806-896 MHz and 902-940 MHz, providing complete 360° coverage versus the 180° coverage available from a single antenna. In addition, each of the antennas can be independently adjusted so that each sector can be optimized for elevation beam tilting.

Huawei Technologies announced the launch of its UMTS Distributed NodeB solution with enhanced features of reduced TCO (total cost of ownership). According to the company, this new solution is able to effectively reduce TCO by more than 30% as well as speed up the completion of a 3G network construction. The solution aims to reduced difficulties associated with site acquisition by breaking the NodeB into two function units of RRU (Remote Radio Unit) and BBU (Base Band Unit) while still in accordance with the CPRI (Common Public Radio Interface) standard. Compared with the traditional BTS, the structure of Huawei's solution cuts down power consumption by more than 1/3 of the original usage.

Motorola has expanded the capacity of its Multimedia Messaging Service Center (MMSC) to provide scalable growth to support more than 40 million subscribers. In addition to increased capacity and throughput, Motorola's latest MMSC enhancements enable video messaging and picture messaging interoperability. Motorola's MMSC allows for effortless transfer of multimedia information from various MMS-enabled handsets or devices across CDMA, GSM, EDGE, UMTS and IP networks to provide full interoperability between multiple e-mail users on the Internet, and inter-carrier multimedia messaging.

Gemplus has carried out what it claims is the world's first high speed Java SIM card applet download over the live 3G infrastructure of 3 Hong Kong. Using a faster and more powerful communication channel based on USIM and OTA technology for 3G1, Gemplus was able to download a data applet over 3 HK's live network onto a 3G video phone at a speed of 384 kbit/s. Download capability at this speed means that operators will be able to maximize the potential of large USIM cards sized 128kb and above, offering faster and more reliable card administration, such as profile management and applet downloading, dynamic memory management, service deployment and post- personalization.

Digita, Elisa, MTV, Nelonen, Nokia, Sonera and YLE (The Finnish Broadcasting Company) are starting a unique mobile TV pilot in Finland. The project tests mobile TV services and consumer experiences, as well as the underlying technology, with 500 users in the Helsinki capital region. The mobile TV test uses IP Datacasting (IPDC), which conforms with the DVB-H standard. At the end of 2004, ETSI adopted DVB-H as the standard for European mobile television services, enabling the simultaneous transmission of several television, radio and video channels to mobile devices.

Nortel has demonstrated a significant increase in data throughput using beyond 3G MIMO (multiple-input, multiple-output) and OFDM (orthogonal frequency division multiplexing). In Ottawa, Nortel demonstrated large information transfers with peak data rates at 37 Mbps over a standard 5MHz PCS mobility band, taking into account noise and fading conditions found on a real-world cellular network. The test network showed that with OFDM and MIMO, wireless subscribers can download a 128 MB file in approximately 30 seconds.

Orange UK and Wanadoo have successfully tested the IP Multimedia Subsystem (IMS) as a reference solution for future convergence applications in fixed and mobile networks. In this project, Siemens provided end-to-end expertise as an equipment supplier, combining solutions from the fixed network, mobile network and end device sectors. To test the new reference solution, France Telecom set up a trial on lab test with a commercial version of IMS, using the standardized platform for combined voice and data services, and enhanced it with a host of features for fixed-line network customers. The selected solution is based on the TISPAN architecture approach. TISPAN, a technical committee within ETSI that is responsible for "Telecommunications and Internet converged Services and Protocols for Advanced Networking", is preparing specifications for a first release of the NGN standards to provide IP-based multimedia services for mobile and fixed networks users. The testers integrated a Voice Media Gateway in order to link the different voice and data transmission technologies on the fixed and mobile networks. Ericsson has also demonstrated true convergence with a suite of end-user services running concurrently over its commercially available IMS solution. Ericsson has IMS deployments and trials with 27 fixed and mobile operators, for services such as Push-to-Talk-over-Cellular (PoC), Combinational Services, IP Telephony and IP Centrex. Nokia also announced it successfully demonstrated live IP multimedia applications based on its 3GPP2/3GPP-compliant IP Multimedia Subsystem over a commercial CDMA2000 network. Nokia claims to be the first company to complete this demonstration, broadening its IMS capabilities to include CDMA in addition to the evolutions of GSM technology. The demonstration included interoperability between GSM/GPRS terminals and CDMA terminals, as well as with CDMA 1xEV-DO Release 0-capable laptop computers.

Alcatel and Datang Mobile have demonstrated a live end-to-end TD-SCDMA solution in Beijing. The demonstration, representing a significant milestone in the industrialization of TD-SCDMA, integrated Alcatel's core network solution

and Datang's mobile radio access solution, and terminals. During the event, a range of 3G/TD-SCDMA applications including video calling, web browsing, file downloading and video streaming at data rates that reached 384kbit/s were demonstrated.

Engineers at Purdue University have developed a technique that could result in more accurate ultra wideband (UWB) radio signals for ground-penetrating radar, radio communications, and imaging systems designed to see through walls. The researchers first create laser pulses with specific "shapes," which precisely characterize the changing intensity of light from the beginning to end of each pulse. The pulses are then converted into electrical signals for various applications. By controlling the shapes of laser pulses, the researchers are able to adjust the frequencies of the resulting radio signals and to produce signals with higher frequencies than are otherwise possible. Shorter signals make it easier to screen out interference and enhance image resolution.

Japan's OMRON has shown a facial recognition technology that can be incorporated into mobile phones. Camera equipped mobile units enabled with the 'Okoa Vision Face Recognition Sensor' require no additional hardware. Users register their own face image to their unit with the unit's camera. The identification process takes less than a second from snapping the photograph. The sensor tests successfully more than 99 times in 100, and is fully Symbian, BREW, embedded Linux, and ITRON OS compatible.

The UK Government is to commission research to identify the future direction of mobile phone technology and the future needs for mast developments. The research will also look at the potential for increased sharing of masts.

Mobile Phones and Health Issues

A new study claims to have found no link between the use of cell phones and the risk of developing a brain tumor. The study is published in the April 12 issue of Neurology, the scientific journal of the American Academy of Neurology. The Danish study questioned 427 people with brain tumors and 822 people without brain tumors about their cell phone use. The study found no increased risk for brain tumors related to cell phone use, frequency of use, or number of years of use. For 27 people with brain tumors and 47 people without brain tumors, researchers obtained phone records from cell phone companies to document the amount and length of calls and compare the actual calls to what participants reported. Those results found that people accurately remembered the number of calls they made, but did not accurately remember the length of those calls. But there were no differences between the two groups on how well they portrayed their cell phone use. The study author noted that there have been few long-term cell phone users or heavy cell phone users in any of the studies. The researchers also found that brain tumors did not occur more frequently on the side of the head where the phone was typically used. The study was supported by the European Commission Fifth Framework Program, International Union Against Cancer, International Epidemiology Institute, and Danish Cancer Society.

Japan's mobile phone operators, NTT DoCoMo, KDDI, Vodafone K.K. and TU-KA Cellular Tokyo have reported interim findings that radio frequency energy from mobile phone base stations does not affect human cells. Using four human cell lines, two containing established infant and fetal fibroblast cells and two containing cerebral tumor tissues, and examining about 20,000 genes in the human genome (approximately 40,000 genes have been identified), researchers found no effect on cell proliferation, gene expression profile or DNA single-strand breaks. According to the companies, the results seem to indicate the safety of radio waves, as the radio waves used in the experiment were up to 10 times stronger than the limit set forth in radio frequency radiation protection guidelines for base stations. Mitsubishi Chemical Safety Institute provided support for the research. The findings will be announced at the Bioelectromagnetics Annual Meeting 2005 from June 19 to 24 in Ireland and have also been submitted to the BEMS Journal.

During its two years of operation, the Greek project HERMES has carried out more than 1,700,000 RF radiation measurements from mobile telephony in all the 17 monitoring stations all over Greece. The results of these measurements demonstrate that electromagnetic radiation emitted by the mobile telephony base stations appears to be tenths or thousands of times below the lowest reference levels that have been set.

3G News

NetCom has launched its UMTS network in Norway. The company is launching NetCom Connect, which is a smartcard for PC laptops that provides Internet access at broadband speed. More than 240 towns and urban areas will receive UMTS coverage when the network opens. This means that about 3.5 million Norwegians will have access to UMTS. In addition, NetCom is making extensive progress in building out EDGE. These build-outs will mean that 4.3 million Norwegians, or 95% of the population, will have access to mobile broadband during 2006.

mobilkom austria has announced it is the first provider to make full-coverage 3G service available throughout Austria. While 60% population coverage for UMTS was achieved by the end of 2004, the enhancement of the UMTS network through EDGE will make population coverage of 95% possible.

VIPnet has launched the first commercial UMTS service in Croatia. The service is offered in 91 cities and the operator is set to achieve a 25% population coverage within two years. The operator already introduced EDGE technology in Croatia last year. In Romania, Connex has also announced the launch of its 3G services in 8 cities.

Iusacell and Lucent Technologies have announced an agreement to deploy a super-fast, 3G CDMA2000 1xEV-DO network in the cities of Mexico, Monterrey and Guadalajara. Lucent will upgrade existing Lucent-supplied base stations to support CDMA2000 1xEV-DO technology. As part of the project, Lucent will also provide additional mobile switching centers and its Flexent Mobility Server to provide an open IP interface to the data network. Lucent has also announced that it has equipped nearly 10,000 base stations worldwide to support CDMA2000 1xEV-DO technology. According to Dell'Oro Group, Lucent remains the world leader in CDMA technology, with more than twice the market share of the nearest competitor.

Orange has launched technical and marketing trials of UMTS TDD targeting the enterprise market in Lille, France with equipment supplied by IPWireless. The trials will enable Orange to assess the real-time performance of TD-CDMA, and notably the coverage area, the capacity, the number of simultaneous users per carrier, and the coexistence of TDD and FDD. IPWireless has also announced that Woosh Wireless will expand, with an additional 180 UMTS TDD base stations, its New Zealand broadband network.

The company, that deployed its UMTS TDD network in 2003, has already passed the 10,000 subscriber mark.

IPWireless has demonstrated a complete high-speed packet-based data and voice solution designed for UMTS operators with access to spectrum in the 450MHz band. The solution uses the company's Multi Chip Rate technology to support three chip rates 1.28Mcps, 2.56Mcps and 3.84Mcps. The UMTS450 solution also supports multi-band devices allowing users to roam to the 1900/2010MHz IMT2000 TDD bands. The UMTS450 NodeB base station supports 1, 2 or 3 channels in the 450MHz band.

Tele2 AB has announced the launch of the first world-wide free TV station available on 3G mobile phones, via its own TV channel Tango.TV (TTV). The development center located in Luxembourg is in charge of applying the convergence strategy and has also created an Internet radio, Sunshine Radio Luxembourg, also available on 3G phones.

Motorola and MTC have announced the completion of the first UMTS point-to-point video and voice calls across a live air connection in Kuwait. As part of this trial, Motorola has delivered a trial UMTS network to MTC, including Horizon 3G base stations, which offers a low dropped-call rate that is comparable to high-performing GSM levels.

NTT DoCoMo has announced that the number of subscribers to DoCoMo's 3G FOMA service has surpassed the 10 million mark less than three and a half years since the service's launch on October 2001. FOMA service is currently available in 99.9% of populated areas and all stations of both the Tokyo Metro and Toei subway networks. KDDI and Okinawa Cellular have also announced that their total number of 3G subscribers has exceeded 18million at the beginning of April. The companies launched their au 3G service on April 2002.

According to the UMTS Forum, global subscriptions to 3G/UMTS networks had already reached, at the beginning of 2005, 16 million on more than 60 networks. There are already more than 100 WCDMA devices available, including handsets and PC card products from Asian, European and US vendors. Even in developing countries like Africa, where the uptake of 3G was anticipated later than in other markets, the end of 2004 has seen the launch of 3G/UMTS networks in South Africa and Mauritius, while other WCDMA networks are expected to be tested in Northern Africa by the end of 2005.

The GSA association has said that there were 64 WCDMA networks in commercial service in 31 countries at the end of 2004. The networks deliver 3G services to over 16.2million subscribers. According to GSA, 56% of the 129 WCDMA license holders in 43 countries have already launched, or are close to do so, their 3G service. GSA also revealed that 123 GSM/GPRS operators in 72 countries have committed to the EDGE upgrade; of these a total of 43 networks in 32 countries have already launched commercial EDGE-enabled services.

The CDMA Development Group (CDG) reported that CDMA2000 added 21.5 million new subscribers in the 4Q, ending the year with nearly 147 million users. Asia has the largest base of CDMA2000 users: 73million, or nearly 50% of all CDMA2000 subscribers. The CDG also reported that there are 31 CDMA2000 operators serving nearly 9 million subscribers in 18 countries.

HSDPA News

Japan's Vodafone K.K. has obtained a license from the Ministry of Internal Affairs and Communications to conduct field tests for HSDPA (High Speed Downlink Packet Access) using experimental radio stations. The field test will be conducted in the Tokyo Metropolitan area using the 2GHz frequency band.

Lucent Technologies and eAccess have announced plans to collaborate on the development of a W-CDMA trial network to enable eAccess to evaluate mobile voice, high-speed data and multimedia services. The network will incorporate HSDPA technology and Lucent's IP Multimedia Subsystem (IMS) solution. eAccess is preparing for the potential release of new licenses by collaborating with Lucent to deploy a trial network in the 1700 MHz spectrum band for the introduction of new innovative services for the Japan market.

Cingular Wireless and Lucent Technologies have announced that the two companies have successfully completed, what they claim is the first HSDPA data calls on the UMTS trial network deployed by the two companies in the Atlanta market. Lucent and Cingular also demonstrated performance improvements that have been implemented in the trial network, including reductions in transmission delays. These successful tests follow Cingular's recent announcement of plans to roll out a nationwide 3G UMTS/HSDPA network. The calls were completed using Lucent's end-to-end commercial UMTS solution, including Lucent's Flexent OneBTS base stations (Node Bs) – which support HSDPA – Flexent Radio Network Controller (RNC), as well as UMTS packet core solution including Lucent's Flexent Serving SGSN and GGSN, along with an HSDPA test terminal.

Ericsson has demonstrated 11 Mbps high-speed data downloads and streaming applications over HSDPA phase 2 and a live WCDMA system. HSDPA, phase 2, increases the WCDMA system capacity and allow for peak rates up to 14 Mbps. The HSDPA demonstration run on a commercial system such as the one Cingular Wireless will launch later this year. Ericsson will provide a portion of Cingular's UMTS/HSDPA packet core and radio network equipment for both the 850 and 1900 MHz bands.

Motorola has released initial data from HSDPA trials with five major European operators. Speeds of 2.9Mbps have been recorded at the edge of an outdoor UMTS cell using a single HSDPA device. Motorola set up a menu of test options for the participating operators to choose from to allow them to create independent test environments.

Siemens successfully demonstrated the data transfer via an HSDPA network to a notebook with an HSDPA card in its PCMCIA slot. The HSDPA-capable Node B 880 transferred data to a notebook at a speed of almost 2Mbit/s. The HSDPA end-to-end solution from Siemens will be available for commercial use as second half of 2005. In addition, the card is equipped with quadband technology and is therefore suitable for use in all GSM, GPRS and EDGE networks around the world. The card is based on Data Suite software and supports simple plug-and-play functionality with the Windows operating systems Windows 2000 and Windows XP.

Nortel and Sierra Wireless completed an initial series of live HSDPA test calls, including what they claim is the industry's first using a data card product slated for commercial release. The test calls used Sierra Wireless AirCard 850 wireless wide area network cards and commercial UMTS network equipment from Nortel. The calls were made from a laptop computer in a moving automobile with connection speeds averaging 800kbps (with peak data rates in excess of 1Mbps). Nortel recently announced plans for a major Pan-European HSDPA network deployment with mmO2 and is working with a number of other leading global operators on HSDPA trials and deployments in 2005. The

broadband calls were completed in and around Nortel's Wireless Center of Excellence in Chateaufort, France using commercially-available UMTS Base Transceiver stations.

Qualcomm announced the MSM6260 chipset and system software solution for WCDMA/HSDPA and GSM/GPRS/EDGE to increase the reach of cost-effective, higher-speed wireless data solutions. The MSM6260 Multimedia Platform chipset supports peak data rates of 3.6 Mbps to address global demand for high-speed wireless data devices. With the MSM6260 solution, OEMs can develop HSDPA devices at attractive price points that offer global roaming and advanced wireless multimedia. Qualcomm also announced a tri-band WCDMA/HSDPA and quad-band GSM/GPRS/EDGE radioOne solution to enable true global roaming between WCDMA markets in Europe, North America and Asia.

Nokia launched the Nokia Internet High Speed Packet Access (I-HSPA) solution, a 3GPP standards based simplified network architecture innovation from Nokia, implemented by adding I-HSPA functionality to an existing Nokia WCDMA base station. The basic performance of Nokia I-HSPA will resemble that of the 'traditional' High Speed Packet Access (HSPA) solutions, namely High Speed Downlink & Uplink Packet Access. This means that the downlink bit rate can be 14.4 Mbps and the uplink 5.8 Mbps. Nokia is demonstrating HSUPA (High Speed Uplink Packet Access), a UMTS/WCDMA uplink evolution technology currently being standardized in 3GPP, in addition to HSDPA.

Spectrum Licenses

Bulgaria has issued three 20-year UMTS licenses. The companies awarded such licenses are: Mobiltel AD, Cosmo Bulgaria Mobile and Bulgarian Telecommunications. Sweden has invited operators to apply for a 15 year license for digital mobile telephony in the 450MHz band. The new mobile system should replace the analogue NMT450 in relation to voice services. The company that will obtain the license will have to cover 80% of the landmass of each of the counties that makes up Sweden. Malta is planning to offer a third GSM license and new 3G licenses. The telecoms regulator has already published its strategy with regard to the allocation of such licenses. One of the conditions considered is that a nationwide rollout will have to be completed within 5 years from the date the spectrum is being assigned. Three frequency bands will also be made available for broadband wireless access applications. Afghanistan has also announced plans to award two further GSM licenses in the country. The companies being awarded the licenses (900MHz and 1800MHz) should start commercial service in January 2006. Germany has announced that it is to offer additional spectrum (10MHz paired) for the GSM network operators. The country's telecom regulator (RegTP) has also invited interested parties to comment on the future use of the returned UMTS licenses. Mobilcom returned its UMTS frequencies at the end of 2003 whereas Quam will not be building a UMTS network. Consultation is also being made on the future usability of the UMTS extension band (2500-2690MHz).

Vodafone Japan has applied to the Ministry of Internal Affairs and Communications for licenses to operate WCDMA experimental radio stations on the 1.7GHz frequency band, hoping to be able to provide future commercial services in this band. The operator is planning to conduct field tests to investigate radio wave propagation characteristics, building shadowing effects and in-building penetration loss.

Forums and Industry Alliances

The WiMedia Alliance and the MultiBand OFDM Alliance have announced their merger into a single organization. The WiMedia-MBOA is conducting an intellectual property review of the MBOA-SIG's physical (PHY) layer specification. The organization is also finalizing the MBOA-SIG's MAC layer specification and has begun defining its certification and interoperability program. The WiMedia Alliance has also announced that the FCC has granted the MBOA-SIG's request for waiver of certain measurement procedures for the multiband OFDM standard for UWB. The waiver paves the way for companies producing UWB devices compliant with the MBOA specifications to get FCC certification for shipment.

The Mobile Imaging and Printing Consortium (MIPC), an industry group developing solutions and implementation guidelines for printing images captured with camera phones, have announced their first set of guidelines. The guidelines leverage existing connectivity technology standards and solutions, such as Bluetooth, printing from memory cards and PictBridge. Consumers can expect seamless interoperability between a broad base of mobile phones and printers. More information in: http://www.mobileprinting.org/developers

The ZigBee Alliance has announced four ZigBee-compliant platforms from Chipcon, CompXs, Ember, and Freescale Semiconductor. Using testing services provided by the Alliance's official test houses, National Technical Systems and TUV Rheinland, and leveraging analysis tools from Daintree Networks, the Alliance conducted extensive testing on these platforms to ensure complete interoperability. Since the ratification of the ZigBee specification, the Alliance has been finalizing a formal compliance testing program for the ZigBee platform, which is a software and hardware design to enable OEMs to develop a wide range of ZigBee based products.

Motorola and Skype, an Internet telephony company, have announced their intention to work together leveraging Motorola's strength in seamless mobility, advanced technologies, mobile devices and accessories and Skype's rapidly-growing global user base and rich voice and messaging communication tools. The initial collaboration will be on co-marketing of new Motorola 'Skype Ready' companion products, such as Bluetooth headsets, dongles, and speakerphones, as well as delivery of the Skype Internet Telephony experience on selected Motorola mobile devices.

HP and Nokia have announced an agreement to deliver a jointly developed, integrated solution for the processing of forms using mobile technology. The Mobile Forms Initiative allows users to create forms, collect the forms' data via a mobile device, and then transmit it in real time to an enterprise's IT infrastructure, where the data can be saved, shared and printed. This solution addresses a critical need for enterprise and public sector customers who require paper-to-mobile workflow capabilities to communicate information traditionally captured on paper forms.

PMR and Public Safety

Samsung Electronics has announced the development and demonstration of a working PTA (Push-to-All) solution. This total mobile communications solution incorporates the existing PTT (Push-to-Talk) one to multi-user voice technology with the one to multi-user video conferencing ability of PTV (Push-to-View) and multimedia file sharing function of PTD (Push-to Data). The core benefit of PTA handsets is the synchronous video conferencing. Samsung Electronics plans to offer a commercialized PTA solution handset using not

only EV-DO technology but also EDGE, UMTS, and WiFi standards.

Motorola has announced that Buffalo, MN has gone live with its Mesh Network solution, offering high-speed mobile broadband access to police and other city employees. Motorola's Mesh Networks technology was originally developed for the military battlefield in order to provide instant, ad-hoc communication networks where fixed infrastructure was not available or deployable. The technology is capable of delivering seamless broadband connections to vehicles moving at highways speeds. The Buffalo system also features Motorola's unique Multi-Hopping capabilities that turn each mesh-enabled radio into its own router/repeater. This capability allows users to hop through other users to reach network access points. As a result, every user makes the network stronger – extending network coverage and creating more data paths through the network. Motorola's Mesh Network products also offer fast and accurate tracking capabilities without the use of GPS satellites. The city is using the mesh network to power public safety mission-critical applications, including in-field reporting, and access to the state's criminal database from the officer's patrol car.

China's Ministry of Railways has selected Nortel to provide a digital wireless communications network for the world's highest altitude rail service – the Qinghai-Tibet Railway. This will be the first commercial use of GSM-R technology in China, following a year-long trial of Nortel's technology over more than 186km of track built on perennially frozen land at altitudes up to 4,780 meters above sea level. The 1,142-kilometer Qinghai-Tibet Railway will be the first in China to incorporate GPRS for data applications.

PSA Singapore Terminals, the world's largest transhipment hub, will be implementing Motorola's TETRA digital radio system at its four container terminals and its multi-purpose terminal Pasir Panjang Wharves. PSA Singapore Terminals is the largest port user in the Asia-Pacific to deploy the TETRA system, which offers integrated voice and data capabilities. Motorola has also announced it has begun the deployment of a nationwide TETRA network for the Serbian Ministry of Interior and the Police Force. Nokia will be implementing an advanced radio communications system for Abu Dhabi Police (United Arab Emirates). The new communications network, based on TETRA technology, will cover the whole of the Abu Dhabi Emirate. Nokia will provide the complete solution, including the core Nokia TETRA network, more than a hundred Nokia TB3 TETRA base stations, a large number of dispatcher stations, a centralised network management solution Nokia NetActTM for TETRA, and a comprehensive set of services. Nokia has also won the contract to supply the radio communication network for the Civil Protection and Transmission Department of the Turin Municipality. The system, that according to the Finish manufacturer will be the first significant implementation of its kind in Italy, will be put into operation at the beginning of 2005. The city of Lyon Police Force has decided to modernise their mobile radio communication network using digital TETRA technology and has signed a contract with AMEC Spie Communications to deploy a Nokia TETRA system. The network will be used to secure large national and international events that are organised in the city of Lyon, such as G8, City-Net, Eurocités, and the annual marathon. The network deployment project has started, and it is estimated to be finished during year 2005.

Wireless in vehicular environments

A stable Wi-Fi broadband internet connection via satellite was successfully tested aboard a high-speed train – the Paris-Brussels route operated by Thalys. The record bandwidth attained was 4 Mbit/s downstream and 2 upstream at 300 km/h, comparable to the quality of an ADSL+ connection, a faster variant of DSL. This test was supported by ESA and was implemented by the Anglo-Belgian operator 21Net with Siemens as technology partner. Siemens integrated the Wi-Fi network in the passenger cars and provided the complete management system including authentication and billing. The pilot project will run for a period of three months on one train only. If proven successful, Thalys will equip its entire fleet of 28 trains running on the Brussels-Paris route with super fast internet. When paying for a seat, each passenger receives a password and ID for logging on to the wireless broadband interconnection. As soon as the passenger logs on, the authentication information is sent to the central Network Operations Center (NOC) of Siemens Belgium via satellite. The NOC houses the Network Management Center where Siemens manages the authentication of users for 21Net and assimilates the time-based billing data.

Icomera has announced a contract with Scandinavian train operator SJ to equip its fleet with Icomera's Wireless Onboard Internet service. The deal will also mark the roll-out of Icomera's 3G/satellite-enabled WiFi service. GNER is also currently testing the 3G system on its East Coast route in the UK.

As part of the Railnet project, a project of Deutsche Bahn and T-Mobile, a pilot trial will be launched this year to provide wireless internet access using WLAN in ICE high-speed trains. The pilot project, launched between Cologne and Dortmund, will fully equip 20 large stations as so-called hotspots.

Redline Communications has announced that Nomad Digital has selected its broadband wireless technology for a ground-breaking high-speed Internet project for Southern Trains. The project – a joint effort between Nomad, T-Mobile and Southern Trains – will see the deployment of Redline's AN-50e broadband wireless platforms on selected trains along a 90km corridor route between London and Brighton. The pilot deployment features the AN-50e platform on an express commuter train, with more than 30 Redline units installed on base stations spaced at 3 km intervals along the route. Some links can pass data to and from the moving train at 32Mbps, making this what the companies claims is the fastest data link to a train anywhere in the world.

Onboard mobile telephony and Internet access, will soon be available on new Airbus aircrafts. According to the OnAir Board chairman, the number of passengers in the addressable market for onboard GSM telephony will be over 700million by 2009. Previous Airbus GSM trials demonstrated successful communication to and from mobile phones on board to mobile and fixed telephones on the ground. A survey sponsored by the Association of Flight Attendants and the National Consumers League has revealed that 67% of air travellers would prefer current airborne mobile phone restrictions to remain in place. 70% of respondents also indicated that if the use of mobile phones is permitted on planes, airlines should separate out cell phone users on flights.

Wireless LAN & WiMAX

O2 and Siemens have successfully completed a test of Alvarion's BreezeMax 3500, a WiMAX (Worldwide Interoperability for Microwave Access) solution that was used to provide broadband services to households and small businesses in the Gleann Cholm Cille valley (Ireland); this location was selected because of its challenging terrain.

BreezeMAX is a third-generation OFDM platform with advanced NLOS functionality and is designed for operators to offer broadband IP-based voice and data services. Alvarion has also announced it will cooperate with Lucent to deliver a converged networking solution to service providers that includes the seamless interoperability of WiMAX, 3G mobile (CDMA2000 and W-CDMA/UMTS), WiFi and wireline networks.

Airspan Networks will build, in partnership with Yozan, what it claims is Japan's first WiMAX network to cover the Tokyo metropolitan area. Airspan will deploy its AS.MAX base stations and customer premises equipment to enable Yozan to deliver self-installable voice, video and broadband data services. Airspan products include point-to-multipoint BS and an integrated point-to-point backhaul solution. The network trials will be initiated in 2Q of 2005 with commercial rollout at the end of 2005.

Siemens has presented SkyMAX, an end-to-end solution for WiMAX radio. The SkyMAX base station and modems support the IEEE 802.16-2004 standard for stationary IP-based broadband access. SkyMAX is already prepared for an upgrade to IEEE 802.16e, an extension of the standard for mobile use. The SkyMAX products will be available on the market in the second half of 2005. SkyMAX flexibly adapts to diverse frequency channels from 1.75 to 14 MHz with adaptive modulation up to 64 levels.

Fujitsu has launched its MB87M3400 solution, an 802.16-2004-based Systom-on-a-Chip for wireless metropolitan area networks (WMAN). The chip is designed to be used in both base stations and subscriber base stations in NLOS deployments. The chip will work in both licensed and unlicensed radio bands under the 11GHz band. The SoC includes its own RISC processing engine to control the MAC layer. The physical layer uses OFDM 256 modulation.

The WiMAX Forum has selected Cetecom Spain as its official certification laboratory. Acting as an independent body, Cetecom will test and certify WiMAX Forum member companies' products to ensure they meet WiMAX Forum conformance and interoperability standards.

Novatel Wireless has developed a method for enabling wireless devices to efficiently discover the best wireless connection, therefore facilitating inter-system roaming between WiFi and other mobile networks. Current roaming devices are constantly scanning to find the best connection, which results in high battery power consumption. Their technology uses an innovative technique to conserve battery resources by performing a conditional scan. It also unveils smart technology that tracks the regular usage patterns of the subscriber by memorizing periodic modem usage activities and geographical locations.

Computer scientists from the University of California, San Diego (UCSD) have developed SyncScan, a process to achieve practical, fast handoff for 802.11 infrastructure networks. According to the researchers, SyncScan is a handoff algorithm which can cut the time it takes to switch from one Wi-Fi access point to another by a factor of a hundred over existing solutions. The SyncScan solution is a method to continuously monitor the proximity of nearby 802.11 access points. Instead of looking for surrounding access points just when the current signal is running low, a Wi-Fi device with SyncScan regularly checks signal strengths nearby – but only for very short periods of time. These times are picked to precisely coincide with regularly scheduled "beacon" messages sent by all standard Wi-Fi access points. The process eliminates the current need to start from scratch when looking for a stronger signal, and replaces the long scanning delay with many small delays that are imperceptible to the user.

According to TIA's 2005 'Telecommunications Market Review and Forecast', Wi-Fi and WiMAX infrastructure revenues are expected to reach $5.2 billion and $115 million, respectively, in 2005. Spending on Wi-Fi services reached $21 million in 2004 and is expected to increase to $45 million in 2005 and continue to climb at a 99.9% compound annual growth rate (CAGR) to $335 million by 2008. Spending on Wi-Fi equipment rose 31.8% in 2004 to $4.35 billion where as the spending on Wi-Fi infrastructure equipment is expected to total $7 billion in 2008. The number of Wi-Fi hot spots in the US increased more than six-fold from 2002 to 2004, from 3,400 to 21,500; it is expected they will increase to 64,200 in 2008. Spending on WiMAX infrastructure is expected to increase dramatically in the next few years, growing from $15 million in 2004 to $115 million in 2005, a 666.7% increase, and then rising to $290 million by 2008, growing at a 109.7% CAGR. IDC has revealed that the WLAN market increased by 9.3% in 4Q of 2004 compared to 3Q, reaching total revenue of $382.1million. While WLAN client revenue increased by 27%, WLAN infrastructure only increased by 0.8%.

CTIA Wireless 2005

More than 35,000 attendees and 900 exhibitors participated in the CTIA Wireless (http://www.ctiawireless.com/) event that took place in New Orleans from the 14th to the 16th of March.

Nortel announced it plans to offer CDMA2000 1xEV-DO Revision A technology designed to allow CDMA network operators, including Verizon Wireless, to increase revenues through improved high speed data services. Nortel's DO Rev A technology will allow CDMA network operators to provide more feature-rich wireless services such as interactive 3D gaming, mobile music and VoIP. It will also support virtual real-time interactive access to services such as push-to-talk, mobile television, and video telephony. Motorola showcased its fully integrated end-to-end CDMA 1xEV-DO solution, coupled with its IMS. Samsung demonstrated what it claims is the world's first DVB-H handset developed for CDMA networks. With updated Internet Protocol Datacast (IPDC) functionality built into Samsung's CDMA DVB-H phone, the handset enables users to experience interactive mobile television. Philips presented a new 802.11 WLAN semiconductor system-in-package (SiP) solution for mobile phones that reduces transmit and receive operating power consumption, while speeding consumer access to voice, data, and multimedia content through WLAN by up to 500%.

During the event, Qualcomm demonstrated converged IP-based capabilities as VoIP services over EV-DO, EV-DO Rev. A higher data rates, pilot interference cancellation (PIC), and Platinum Multicast. Platinum Multicast allows operators to increase network capacity and reduce the cost of delivering video, audio and other multimedia content to large numbers of users simultaneously over EV-DO Rev. A-based cellular networks. The US manufacturer also showcased QChat push-to-talk solution running seamlessly between CDMA2000 and iDEN air interfaces. Qualcommm demonstrated a new, standards-based wireless digital rights management (DRM) solution for securely managing and distributing media content between mobile and consumer electronics devices. This technology is the result of joint development activity between Philips and Qualcomm. It also announced that the air interface specification for FLO (Forward Link Only) technology will be made available to

an industry-led group, for the purpose of bringing a cooperative specification to standards bodies for ratification. The FLO technology was designed specifically for a mobile multimedia environment and exhibits performance characteristics suited ideally for use on cellular handsets. It uses the latest advances in coding and interleaving to achieve the highest-quality reception at all times, both for real-time content streaming and other data services. The technology also reduces the network cost of delivering multimedia content by dramatically decreasing the number of transmitters needed to be deployed.

PCTEL unveiled the ASPDM913U, a new dual band elevated feed antenna designed to provide optimal coverage of both cellular and PCS frequencies with 3 dB of gain, and without a ground plane. The company also introduced its new SeeGull LX Dual-Mode Scanning Receivers, which provide simultaneous RF measurements for carriers migrating from 2.5G to 3G. PCTEL also launched its CDMA CLARIFY Interference Measurement Solution for detecting and measuring interference in cellular networks. Finally, PCTEL showed its Roaming Client, a software solution that enables wireless subscribers to roam among 802.11 Hot Spot networks without interruptions in service.

RF Micro Devices announced production shipments of the RF8900, which integrates Bluetooth communication, GPS technology, and associated software into what the company is calling a "converged solution" for "puck-style" devices that transmit location information wirelessly. Willtek Communications announced the new 4921 RF Shield, a RF shielding solution for use in the testing of wireless devices, such as 3G cellular phones, data cards, and WLAN equipment in large service centers and manufacturing lines. Digi International introduced Digi Connect Remote Gateway GSM, a serial-to-wireless GSM EDGE gateway that connects remote serial devices via Cingular Wireless network. Powerwave Technologies introduced its next-generation 1900MHz multi-carrier power amplifier (MCPA) that supports multiple wireless protocols and provides a migration path from GSM/EDGE to WCDMA. Primus Telecommunications unveiled its entry into the US market as an MVNO operator.

CeBIT 2005

CeBIT 2005, a trade fair for the ICT sector, took place between the 10th and 16th of March in Hannover (Germany). Top themes at this year's CeBIT were Mobile Services, Digital Lifestyle, IT Security and IT Outsourcing Services. In the Telecommunications domain, the main highlights were UMTS and Voice over IP. A big buzzword at CeBIT 2005 was convergence, i.e. the convergence between information and telecommunications technology, and consumer electronics. Complete information on the event can be found in http://www.cebit.de/

At the event, Siemens presented a completely new Gigaset W-LAN product family, which enables data, picture and sound transfer at twice the previous speed via cordless 108 mbit technology with a router, PC card, USB adapter and repeater. The E-Mail Push and PIM (Personal Information Manager) synchronization solution from Siemens is one of the innovative new applications for mobile corporate communication presented at CeBIT. For mobile coverage of GSM/EDGE networks within buildings, Siemens presented a nanoGSM Base Station Subsystem, an IP-based solution. The system comprises small, cost-efficient 'indoor base stations', which are integrated into existing company IP networks. Siemens also presented a device prototype equipped with a DVB-H receiver, stereo and a large VGA touch display. The "New Interactive Phone" is a test product which projects visual information onto smooth surfaces such as a desk. Together with a Bluetooth pen, the projection area functions as a virtual keyboard for data entry.

Lucent Technologies announced a contract from German mobile operator E-Plus to provide optimization services for E-Plus' 3G UTRAN ATM backhaul network. The US manufacturer also announced that Telefonica Moviles has awarded them the deployment of the aggregation edge layer, nationwide, of their ATM network, to carry the voice and data traffic within the UTRAN of Telefonica Moviles's UMTS network. Motorola demonstrated its vision of Seamless Mobility by extending consumer choice and experience with two feature-packed 3G devices, two new stylish and affordable clamshell handsets and a new Bluetooth car communications system for BMW. The BMW communications system automatically connects to a compatible phone with Bluetooth wireless technology and synchronises phonebook contacts each time a driver enters the vehicle. Nokia demonstrated its commitment to 3G with its recently launched 3G imaging smartphone, the Nokia 6680 and its EDGE-enabled variant, the Nokia 6681. One of the highlights was the new mobile music solution unveiled by Nokia and Loudeye for operators. It enables operators to offer comprehensive branded mobile music services for their customers, and Nokia announced O2 Germany as the first operator customer.

3GSM World Congress

The 3GSM World Congress took place in Cannes (France) for the last time before moving to Barcelona (Spain) (http://www.3gsmworldcongress.com/). The highlights of the event included the growing momentum of 3G; its continuing evolution with technologies such as IMS and HSDPA and low cost handsets for emerging economies. The GSM Association announced the first results of its initiative to create an ultra low-cost handset segment with a target price of sub-$30. The initiative seeks to extend access to the economic and social benefits of mobile communications by connecting the unconnected in emerging economies. Offering a sub-$40 handset and demonstrating a commitment to achieving the target price, Motorola was unveiled as the successful winner.

Motorola showcased its IP Multimedia Subsystem (IMS) at the event. The Motorola IMS is linked with Session Initiated Protocol (SIP) application servers from IPeria and Ubiquity and media servers from Brooktrout. In addition to video calls and ringback tones, the demonstrations included multiple devices used to showcase packet switch to circuit switch calling; flexible alerting; voicemail; unified messaging; and mobile conferencing. The Motorola IMS is designed to be a robust and highly scalable carrier-grade system that enables convergent VoIP across multiple access domains and open interfaces to 3rd party applications servers.

Siemens demonstrated the transmission of data in real time at a rate of 1Gbps. To achieve this high speed, the researchers combined an "intelligent antenna system" consisting of three sending and five receiving antennas with OFDM. In cooperation with Flarion, Siemens also transmitted data live via FLASH-OFDM and achieved downlink speeds between 1 and 1.5Mbps. Siemens and Flarion are jointly working on products for the 450 MHz spectrum. Siemens also announced it is adding mobile TV streaming and M2Y mobile music to its Media Delivery Solution, a

comprehensive system for video streaming and downloading on mobile networks. With the solutions, operators can administer the contents of their mobile services and charge safely. At the event, Siemens demonstrated a new technical concept for using a mobile phone to place calls over the fixed network. The system uses Bluetooth to pass mobile calls at home over to the fixed network. With this solution, Siemens combines the best of both worlds, mobile and fixed-line telephony, in a single device. At the event, Siemens in cooperation with Monaco Telecom used the nanoGSM Base Station Subsystem, an IP-based solution for providing GSM/EDGE network coverage in buildings, for the first time to provide mobile communication on a ship in the harbor of Cannes. Siemens also said it has developed a Policy Control Server which can be used to control the quality of service (QoS) of multimedia applications in EDGE and UMTS networks. With this server, mobile providers can now control the scarce bandwidth resources themselves and guarantee a specific QoS to the data recipients. PCS-5000 allows a specific QoS to be assigned dynamically to mobile data services, which is guaranteed even under high or varying network loads. To transfer the policy for QoS to the transport level, the Server works closely together with the Intelligent Packet Solution IPS-3000, under an architecture that resulted from collaboration with Cisco. The IPS-3000 has the so-called policy enforcement function and ensures that the application-specific QoS policies are also compliant with the network.

Qualcomm announced its BREW uiOne offering, an open and flexible combination of products and services to enable customized user interfaces (UIs) for mobile phones. The US manufacturer also announced that Release 3.0 of its GlobalTRACS equipment management solution will greatly expand in functionality through the use of configurable sensors that monitor the health of critical construction equipment components. Using up to four sensors, GlobalTRACS 3.0 will monitor customer-determined construction equipment thresholds and durations, providing instant critical alerts that can help prevent expensive damage to engines, transmissions and hydraulics. The sensors will also provide non-critical alert monitoring and historical data delivered on pre-determined schedules for use by maintenance personnel to spot potential problems.

Atrua Technologies demonstrated one-touch controls that provide easy, rapid, and secure access to advanced services. The Atrua Wings detects and converts intuitive finger movements into rich and responsive control capabilities making is easy for consumers to access games, multimedia applications and mobile data services. Openwave announced a partnership with McAfee to help operators secure their networks and protect their mobile subscribers with anti-virus. Gemini Mobile Technologies announced new components to its HyperScale Messaging center, including the launch of its second generation MMSC and MMS Push Server. Mobile 365 announced upgrades to its inter-operator MMS service, including improved inter-operator transcoding capabilities, multi-lingual, legacy-style delivery support and enhanced international routing capabilities. Quorum Systems introduced the Sereno QS2000, a single-chip transceiver that offers multi-mode operation. The solution integrates support for 802.11b/g and GSM/GPRS/EDGE technologies. Nvidia announced its latest wireless media processor (WMP), integrating highly realistic 3D graphics, and multi-megapixel still imaging. Radcom announced Hutchison 3G has selected its Cellular Performer system to provide monitoring and troubleshooting on a UMTS network in Australia. 724 Solutions announced that Swisscom Mobile plans to deploy its X-treme Service Activity Manager (XSAM), which standardizes and automates the lifecycle management of content services, enabling mobile operators and third parties to rapidly create, manage and deliver a rich portfolio of advanced WAP, J2ME, HTTP, MMS and SMS-based mobile data services.

US Mobile Market

The Federal Communications Commission (FCC) has adopted rules to open access to new spectrum for wireless broadband in the 3650-3700 MHz band. The Commission adopted a hybrid approach that draws from both the Commission's unlicensed and licensed regulatory models and provides for nationwide, non-exclusive licensing of terrestrial operations in the band utilizing technologies employing contention-based protocols. The Commission also provided an opportunity for the introduction at 3650 MHz of a variety of new wireless broadband technologies, such as Wi-Max, into the band. Under the FCC's approach, there is no limit on the number of licenses that can be granted, and each licensee will be authorized to operate on a shared basis with other licensees on all 50MHz of the band, subject to restrictions in geographic areas occupied by grandfathered Fixed Satellite Service (FSS) and Federal Government stations. Licensees will also be required to register all system base stations electronically with the FCC. To protect the incumbent operations, the FCC established circular protection zones around them – 150 km for FSS earth stations and 80 km for Federal Government stations – and prohibited new terrestrial licensees from operating within these zones unless they negotiate agreements with the incumbents.

The FCC also adopted rule changes for cognitive, or "smart," radio systems. It modified and clarified certain authorization requirements for software defined and cognitive radios to facilitate the development of these technologies. The FCC required that radios that incorporate software designed to be, or expected to be, modified by a party other than the manufacturer provide reasonable security measures to prevent unauthorized software modifications that would either affect the RF operating parameters directly or otherwise indirectly affect the circumstances under which the transmitter operates in accordance with FCC rules. The FCC substituted, at the time of certification, the requirement that the manufacturer of a software defined radio supply software "source code" with the requirement that a manufacturer supply a high level operational description of the software that controls the radio's RF characteristics, and a description of the software security measures employed to prevent unauthorized modifications.

The FCC has adopted an order permitting radiated emissions from ultra-wideband (UWB) transmitters to be measured while the transmitter is in its normal operating mode. This waiver responds to the petition filed by the Multi-band OFDM Alliance Special Interest Group. The FCC is also providing a waiver of the existing measurement procedure, permitting emissions from UWB transmitters to be determined with the transmitter operating normally. The FCC concluded that this would not result in increased harmful interference to licensed radio operations. This waiver applies only to indoor or handheld UWB devices. Further, UWB devices utilizing this waiver may not operate within the 5030-5650 MHz band used for aircraft landing systems and for weather radars. A decision to permit this waiver to apply to UWB devices that operate within the 5030-5650 MHz band will be made upon the completion of the interference investigation

being performed by the Institute for Telecommunication Sciences.

The FCC adopted a flexible approach for licensing the 4 MHz of spectrum in the 800 MHz band currently dedicated to commercial air-ground service. The FCC decided to auction new licenses for this spectrum in three possible band plan configurations and proposed auction rules for this spectrum. In order to further competition and ensure maximum use of the frequency band for air-ground services, the FCC imposed an eligibility limitation to prevent a single entity from holding new licenses for all 4 MHz of air-ground spectrum. Under the eligibility limitation, no more than 3 MHz of spectrum (either shared or exclusive) under the new rules could be acquired at auction or post-auction by a single entity. The FCC determined that the two new licensees must provide air-ground service, meaning service to airborne locations. To ensure protection to adjacent public safety operations in the 800 MHz band, the FCC applied to 800 MHz air-ground licensees the same interference rules and other specific protections adopted earlier this year in the 800 MHz public safety proceeding. Nextel has accepted the FCC's plans to end the problem of interference between the radio operations of wireless carriers and first responders in the 800MHz frequency band. The plan gives Nextel 36 months to sort out and move public safety users, as well as other users, to the 800MHz channels in exchange for 10MHz of spectrum at 1.9GHz.

The FCC has proposed to eliminate unnecessary regulatory restrictions in the 900 MHz spectrum band. Specifically, the FCC proposed amendments to Part 90 of its rules to facilitate more flexible use of the 199 channels allocated to the Business and Industrial Land Transportation (B/ILT) Pools in the 896-901/935-940 MHz (900 MHz) bands. The FCC proposed that the available spectrum in the 900 MHz band be licensed using a geographic licensing scheme. The FCC proposed to license the channels in 19 blocks of 10 contiguous channels each, and one block of 9 contiguous channels.

The FCC has proposed to relax its current ban on the use of cellular telephones on airborne aircraft. The FCC proposed to permit the airborne operation of "off the shelf" wireless handsets and other devices so long as the device operates at its lowest power setting under control of a "pico cell" located on the aircraft, and the operation does not allow unwanted radio frequency emissions to interfere with terrestrial cellular systems. The FCC has asked for public comment on whether the proposal should apply only to devices operating in 800 MHz cellular spectrum, or whether devices operating on other spectrum bands, such as the PCS band or Advanced Wireless Services bands, should be included.

The FCC's auction of broadband PCS licenses ended on February, raising gross revenues of $2,253,802,000. This auction included spectrum returned to the FCC through its recent settlements in bankruptcy litigation, including the settlement with NextWave and other license cancellations. A total of 242 licenses for A, C, D, E, and F blocks of broadband PCS spectrum were offered, and 24 bidders won 217 licenses. These 217 licenses cover 114 markets across the country. Of the 242 licenses offered in the auction, 119 were available only to entrepreneurs in closed bidding, providing smaller businesses with an increased opportunity to participate in the provision of spectrum-based services. Verizon has completed its $3billion purchase of NextWave spectrum, which spans 23 US markets. The spectrum agreement with Verizon covers the 10 and 20MHz licenses in the 1.9GHz range.

Leap Wireless has entered into a definitive agreement with Verizon Wireless to sell certain spectrum licenses and operating assets for $102.5million. The company will sell 23 spectrum licenses (19 of which are not in commercial operation), covering approximately eight million potential customers in 20 markets.

The CTIA Wireless Association has released its semi-annual industry survey in which a 21.7% estimated growth of the wireless subscribers in the US is highlighted. The number of wireless subscribers in America now exceeds 180million, a penetration rate of more than 60%. In 2004, Americans used more than 1 trillion wireless minutes. However, the average local monthly bill grew by only 1.5% since the real price of a wireless minute had fallen by 81%. The survey also indicated that total capital investment in 2004 reached nearly $28billion. IDC has forecasted that US consumer wireless ARPU will trend slowly upward to $48 in 2009 while US business wireless ARPU will increase to $74 in 2009.

Ericsson has signed an agreement with General Dynamics to supply WCDMA wireless equipment and telecom services in support of the U.S. Navy contract awarded to Lockheed Martin to build the Mobile User Objective System (MUOS). MUOS is the U.S. Department of Defense's next-generation narrowband satellite communications system that will provide simultaneous voice, video and data communication for U.S. Army, Air Force, Navy and Marine Corps troops. In the frame of the US Air Force's GPS III System Preliminary Definition phase, Boeing Integrated Defense Systems has awarded a study contract to Alcatel to support the definition of the architecture of the GPS III global integrity as well as the compatibility and interoperability with the Galileo system.

Industry Forecasts and Surveys

According to IDC, worldwide mobile phone shipments totalled 174.3million units in 1Q05, decreasing 12.6% from 4Q04 but increasing 9.2% year over year. Nokia is maintaining first position (30.9% market share), followed by Motorola, Samsung, LG, Sony Ericsson and Siemens. Forward Concepts estimates cell phone shipments in 2004, including inexpensive PHS/PAS units in China, to have reached a record 715million units. The firm has projected that 2005 overall unit sales will increase by 4.5%. The company expects EDGE cell phones will grow by 51%, WCDMA cell phones by 165% and CDMA2000 1xEV-DO by 65%. Gartner estimates the total number of mobile phones sold during 2004 in 674million units, up 30% over 2003 sales. Among the best emerging market performers was Latin America. Strategy Analytics has estimated that global mobile handset sales growth slowed to 10% in 1Q05, with 172million units being shipped. In 1Q04, global mobile handset sales grew 44%. InfoTrends/CAP Ventures projects that worldwide camera phone shipments will grow from 178million units in 2004 to over 860million units in 2009. By 2009, camera phones are expected to account for 89% of all mobile phone handsets shipped. In interviews conducted by the firm, 12.5% of Japanese camera phone consumers indicate that this is their primary camera. In North America and China, consumers are taking about 20 pictures per month. Canalys has said that Nokia has shipped a record 5.4million smart phones in 1Q05. The total number of handsets exceeded 10.7million units with palmOne and RIM following Nokia's performance. Symbian's overall share of the worldwide smart mobile device market rose above 60%, from around 40% a year earlier.

IDC has anticipated that by 2009, over 30million US wireless subscribers will be consuming commercial video/TV content and services over their wireless devices. DRM and ease of use of media player applications will be key consideration for these services to be adopted. The firm has also anticipated that annual revenue will top the $3billion mark by 2009. In-Stat has reported that the number of Push-To-Talk (PTT) and PTT over Cellular (PoC) US subscribers base will grow from 16.8million at the end of 2004 to 33.6million at the end of 2009.

Forrester has predicted that total traffic from all mobile messaging types will grow by 92% over the next five years. However, revenues will only grow by 10%, to reach $27billion by the end of 2010, as unit prices drop. SMS will remain the biggest traffic driver. Juniper Research expects mobile music revenues to account for $9.3billion by 2009. While the downloads of mobile ringtones and realtones will comprise the bulk of revenues ($4.8billion), the market for full-track downloads is expected to increase from just $20million in 2004 to nearly $1.8billion in 2009. The firm also expects gambling service revenues to reach $19.3billion by 2009.

Gartner estimates there will be 3billion mobile subscribers in the world by 2010. The largest portion of growth will come from the Asia/Pacific region. The firm also predicts that by 2009, 20% of enterprise buyers will source fixed mobile convergence instead of buying communications services separately. Deloitte Research has estimated that by the end of 2005, there will be 2billion wireless users worldwide. Voice is expected to account for 80% of wireless revenue this year.

Strategy Analytics has indicated that global margins for wireless operators fell below 40% for the first time in eight quarters. While subscriber volumes rose by 24%, year on year EBITDA was up by less than 4%, resulting in a 15% decline in average margins per user. The heaviest declines in AMPU were in Central and Eastern Europe, and Asia-Pacific.

A new report has highlighted that Africa has seen faster growth in mobile telephone subscriptions than any other region of the world over the last five years. Some of the findings of the study 'Africa: The Impact of Mobile Phones' are: a developing country which has an average of 10 more mobile phones per 100 population between 1996 and 2003 would have enjoyed per capita GDP growth that was 0.59% higher than an otherwise identical country; (twice the size of the growth impact of mobiles in developed countries); 97% of people in Tanzania said they could access a mobile phone, while only 28% could access a landline; over 85% of small business run by black individuals in South Africa rely solely on a mobile phone for telecommunications; 62% of small business in South Africa and 59% in Egypt said they had increased their profits as a result of mobile phones. A copy of the report can be download from http://www.vodafone.com/africa

Other News

In order to boost Europe's leadership in mobile and wireless communications and services, 15 telecommunications companies have launched the eMobility Technology Platform for mobile and wireless communications. The Platform is designed to enhance cooperation amongst industry players, including the research community and public authorities, most notably the European Commission. The overall objective of the Platform is to drive future technology development in mobile and wireless communications in the way that best serves Europe's citizens and the European economy.

NTT DoCoMo has announced that it will stop accepting new applications for PHS (Personal Handyphone System) mobile phone services as of April 30, 2005. DoCoMo will also evaluate the possibility of terminating the service altogether while monitoring future trends in PHS usage by existing customers. The operator has also announced that it will stop accepting new applications for "Pre-Call" prepaid mobile phones on March 31, 2005. The decision is due to persistent fraudulent use.

Book Review

Dirk Pesch, Senior Editor

End of the Line
Joseph Vranich
Published 2004 by
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Price $25

End of the Line, by Joseph Vranich, is published by the American Enterprise Institute for Public Policy Research, a conservative think tank that has been an opponent of Amtrak since it was first proposed. Vranich was commissioned to write the book after producing a previous work, Derailed, in 1997, in which he identified many deficiencies at Amtrak, an organization that he had helped create in 1970 and which he supported for a number of years before deciding that it had not lived up to its promise.

In his latest effort, Vranich again chronicles Amtrak's shortcomings, starting with the unrealistic expectations set for the corporation when it was created, and the many subsequent poor decisions made by several chief executives and other employees of the railroad. The organization's woes are documented extensively in the book's footnotes.

End of the Line does an excellent job enumerating Amtrak's past problems, but it ignores key underlying reasons for Amtrak's current condition. For example, Vranich criticizes Amtrak for not replacing the 12 kV feeder cables in the East River Tunnels. But, the truth is that Amtrak has very limited funds for maintenance and capital work. In fact, under the political pressure to make Amtrak profitable, the corporation was only provided funds for bare maintenance with limited funds available to replace long-time equipment, such as the cited 12 kV cables. If these cables had been replaced, some other high-priority need would have to have been deferred.

Vranich devotes one chapter to building an argument that Amtrak is not an essential transportation system. He provides a chart of cities that are no longer served by Amtrak. But no attempt is made to show which of these cities are served by airlines, which cities Amtrak still serves, or which are not served by airlines. Vranich says it would be cheaper to give every Amtrak passenger an airline ticket than to continue to subsidize Amtrak's long-distance trains, but he ignores the fact that airline travel is not an option for many of Amtrak's passengers.

The section on "hidden subsidies" to Amtrak contains some misstatements. One of Vranich's examples of a hidden subsidy is that certain rail facilities are exempted from local property taxes. He also says that all highways are self-supported through user fees. However, the fact that these same highways are exempt from local property taxes is not described as a hidden subsidy. The truth is that Amtrak pays local property taxes on the freight railroads on which it operates through user fees to those railraods; while its competitors, both air and highway, do not pay local property taxes on the roads and airports. If there is a hidden subsidy in removing property from the local tax rolls, most of the subsidy goes to the highway and airline user rather than to Amtrak.

Amtrak is also criticized for lowering fares while commuter railroads have raised fares. The fact that passengers using these commuter railroads on the same routes as Amtrak are paying substantially lower fares than on Amtrak, even after these fare adjustments, is ignored.

The book is not solely devoted to cataloging Amtrak's flaws and failures, or trying to make Amtrak out to be an unnecessary luxury for the United States. It also provides a suggested solution. Ignoring the poor experience of passenger railroads outside the United States that have been privatized, e.g., in the United Kingdom and in Australia, the book proposes privatizing Amtrak. The successful high-speed lines in Japan and Europe that are held up as examples were built with huge amounts of government money — money that was never provided to Amtrak to build a similar modern infrastructure. The New Tokaido Line and the TGV were built on new rights-of-way provided by the Japanese and French governments. Amtrak had to make due with an existing right-of-way with many more curves. The line from New York to Boston has numerous movable bridges and rail-highway grade crossings, none of which exist on the high-speed lines in Japan, France or Germany. Although a great deal of freight has been removed from Amtrak's Northeast Corridor, the freight trains that continue to use the line substantially increase the cost of maintaining track adequate for high-speed trains. The new high-speed lines in Japan and Europe do not host any freight trains.

Much is made of the decision to acquire a limited number of high-speed Acela trains. Amtrak's previous management was under considerable political pressure to buy the cheapest equipment available. Money became so important to Amtrak in its misguided attempt to become profitable that critical items in the draft specification for the Acela trains were removed after a foreign country agreed to help the supplier with the financial package. The number of high-speed trainsets provided to the railroads in Japan and France far exceeded the number of Acela trainsets that Amtrak was allowed to acquire.

Overall, Vranich does a good job reporting Amtrak's many past mistakes, but he ignores the underlying reasons for the poor state of intercity rail passenger service in the United States, and supports a completely unrealistic reorganization of it.

Land Transportation

Harvey Glickenstein, Senior Editor

A Georgia State Senator has proposed a system of streetcar lines in Atlanta. His proposal includes a line from Buckhead to downtown Atlanta and a feeder route that would bring passengers to MARTA's Lindbergh Station. He is basing his proposal on the experience other cities have had with light rail and streetcar lines that brought business to shops and restaurants their routes.

Los Angeles is re-thinking its ban on new heavy rail transit. Los Angeles uses color coding to distinguish its various lines. The Blue Line, Green Line, and Gold Line are light rail lines that serve the Long Beach corridor, the Century Freeway corridor, and the Pasadena corridor. The 17.4-mile long Red Line is the heavy rail transit line. It operates between downtown Los Angeles and North

Hollywood with a short spur along Wilshire Boulevard to Western Avenue.

The original plans for the Red Line were to expand it both east and west of its current termini. Because of problems with methane gas in the tar pits west of the existing terminus, expansion of the Red Line was stopped. In 1985 Congress passed a ban on tunneling in areas where a risk of methane exists. In 1998 the voters approved a measure that banned the use of local sales taxes on subway tunneling. As a result, the planned eastward extension of the Red Line has been converted to an eastward extension of the light rail line from Pasadena to Los Angeles.

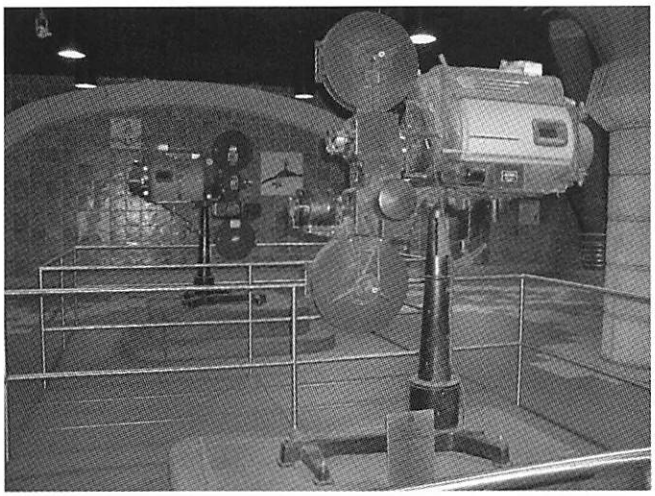


Photo James Irvine

Appropriate platform furniture at Hollywood/Vine Station

Politicians in both Beverly Hills and West Hollywood have called for extending the Red Line further west. By a vote of 11-2, the LA Metropolitan Transportation Authority has decided to study ways to remove the bans on new subway construction in order to extend the Red Line west under Wilshire Boulevard. The measure, which was introduced by a Los Angeles Councilman, would also open consideration of subways in other areas of Los Angeles County in addition to the extension under Wilshire Boulevard.

Qatar and Bahrain expressed interest in construction of a Transrapid maglev system during German Chancellor Schroeder's recent tour of the Middle East. Transrapid is a joint venture of Siemens and ThyssenKrupp of Germany.

A feasibility study of a 500-mile long line to the United Arab Emirates costing around $13 billion will be performed. The cost of a line just between Qatar and Bahrain is estimated at $5.8 billion. It is expected that the maglev line would be able to use the new 28-mile long bridge between the two countries that is under construction and is expected to be completed by 2008. The maglev line could be part of a 1240-mile long high speed line from Kuwait to Oman that is also looking at the feasibility of a conventional high speed rail line.

Bayonne, New Jersey is planning on implementing a 2.5-mile streetcar loop. The loop will serve the 299-acre former Military Ocean Terminal of Bayonne that is in the process of being converted from a United States Army facility to a commercial one called Peninsula at Bayonne Harbor. The streetcars will connect the Peninsula at Bayonne Harbor site to the Hudson Bergen Light Rail System's 34th Street Station. The site is being redeveloped under the aegis of the Bayonne Local Redevelopment Authority. New Jersey Transit donated eight PCC streetcars to the City of Bayonne for the loop, which is expected to be operated by the Twenty First Century Rail Corporation, the operator of the Hudson-Bergen Light Rail. The PCCs were retired in August 2001 from the Newark City Subway.

Charlotte Area Transit System (CATS) held a ground breaking in February for its South Corridor Light Rail Line. The line will be 10 miles long and have 15 stations. It will run from Uptown Charlotte south to Interstate 485. The South Corridor Light Rail Line is scheduled to enter revenue service in Spring 2007.

Dubai is expected to start construction of a Dh12.5 billion light rail system in May, 2005. Dubai projects that its population of one million will reach 3.5 million by 2020, ten years after completion of the project.

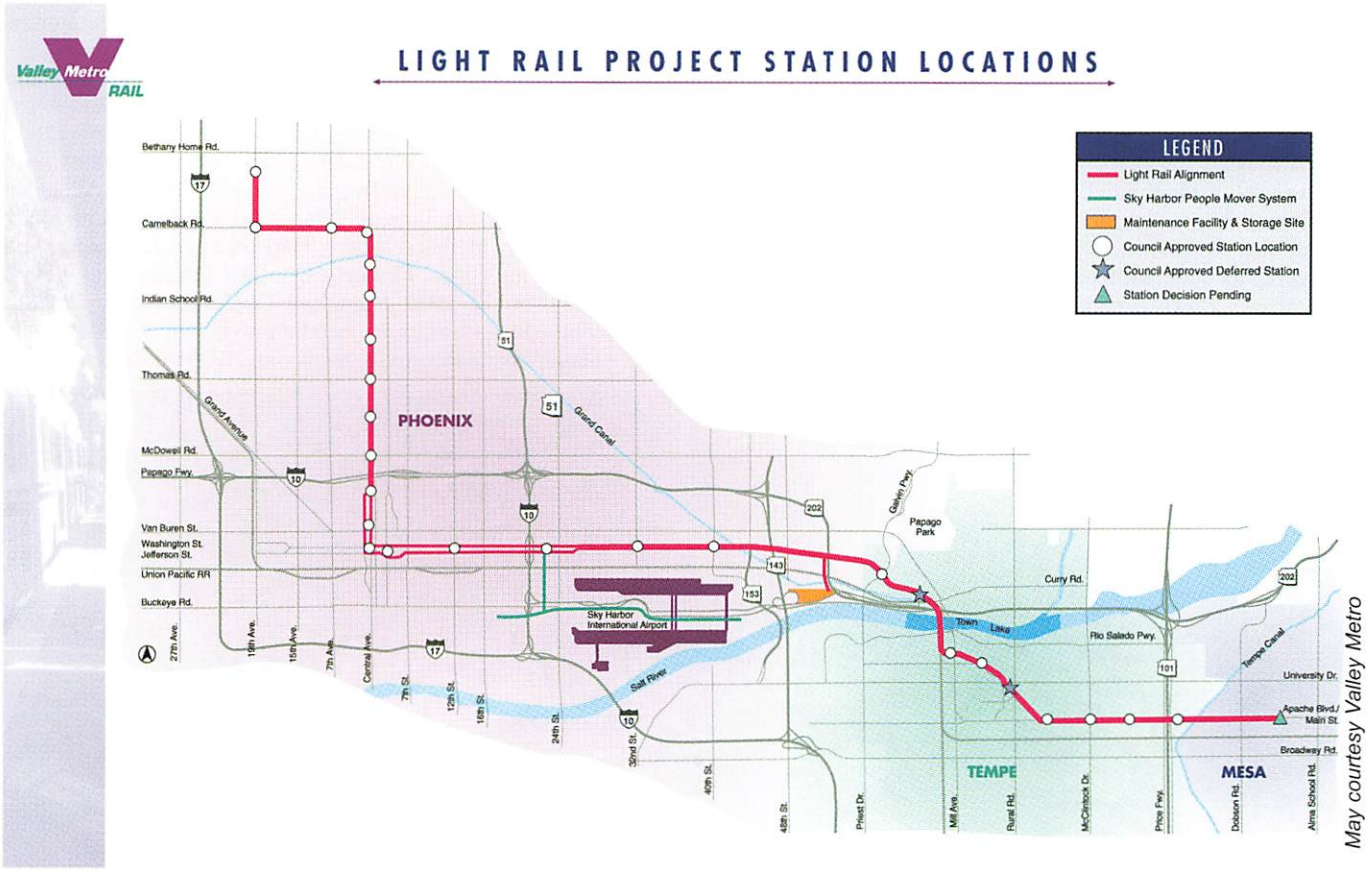
The system will be divided into a 31-mile long Red Line and a 12.5-mile long Green Line.

Valley Metro held a ground breaking for the first section of the Phoenix light rail system at Tempe, Arizona in February 2005. Mayors from the cities of Phoenix, Tempe, Mesa, and Glendale were present when a full-scale replica of the future light rail bridge over Tempe Town Lake was lit up. The mayor of Glendale said that she looks forward to the extension of the METRO system into Glendale in order to connect Glendale to the entire Valley.

In March Valley Metro Rail awarded a $38.9 million contract to design, furnish, and install signals and communications systems on the 20-mile initial line.

A consortium led by Alstom will supply signal equipment for Madrid's four new light rail lines. The lines are expected to enter revenue service in 2007, and will connect Madrid to different municipalities in the north and the west of the Greater Madrid area. Alstom will provide trackside and train-borne signalling equipment and will also be in charge of its maintenance for 3 years on all 4 lines. In August 2004, Alstom was awarded a contract worth 144.6 million euros for the supply of 70 Citadis vehicles for this light rail network.

Russian Railways (RZD) has signed a contract with Siemens to form a joint venture to build 150 high speed trains in the RZD Moscow locomotive works. The trains will be designed to operate at up to 143 mph. They are planned to operate in Moscow-St. Petersburg-Helsinki service. Two other lines radiating from Moscow are also candidates for the high-speed trains.



May courtesy Valley Metro

Valley Metro

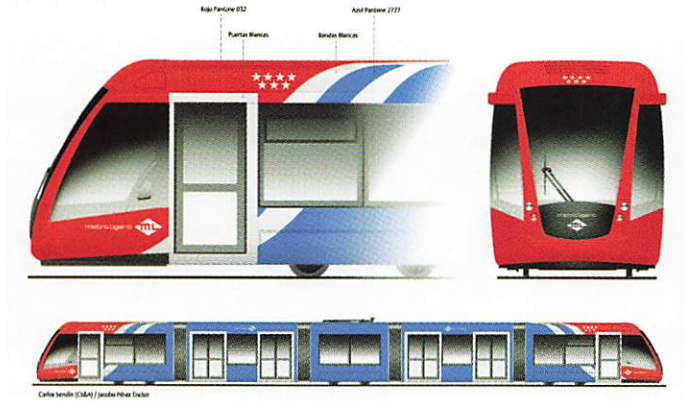


Photo Alstom

Alstom-supplied Citadis trams for Madrid

Photo Siemens

New Russian Railways trains being built with Siemens

Report on Joint Rail Conference 2005

The 2005 Joint Rail Conference, sponsored jointly by the Land Transportation Division of the Vehicular Technology Society of the IEEE and the Rail Transportation Division of the ASME, was held at the Pueblo Convention Center at Pueblo, Colorado on 16-18 of March. The Conference started in the early morning of March 16th with a group of more than fifty enthusiasts enjoying an exciting tour to the 53 acre facility of TTCi. The tour includes a walking tour to the

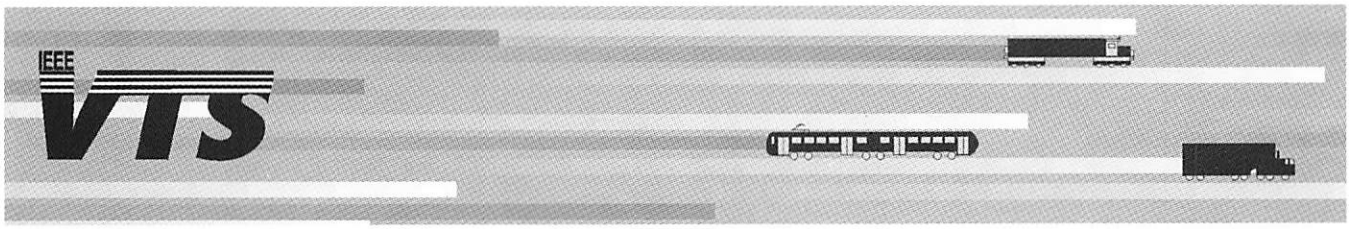
Rail Dynamics Lab and Center Services Building to see the Crash Test Car(see the figure below), plus a riding tour to Test Track Substations, Component Test Lab, and Emergency Response Training Center. After the tour the group joined the AAR Research Review participants for a picnic style lunch at TTCi for Accelerated Service Testing Facility. After lunch the Conference starts technical sessions along with table-top exhibitions.

Over 120 people participated in the Conference from all over the world including Australia, Denmark, Italy, Taiwan, as well as from Canada and the USA. Fifteen Electrical Engineering-related papers and twenty-one Mechanical Engineering-related papers were presented on a variety of technical topics from "Communications Based Train Control (CBTC)" to "Progress in Locomotives, Freight Cars and Improved Performance Issues". All papers generated a great deal of audience interest and questions.

At the Conference Luncheon the IEEE VTS LTD Chair, Margaret Burnett, LTK Engineering Services, passed the gavel to the incoming Chair, Denise Burleson, Lea+Elliot, Inc. The other officers elected for 2005-2006 were: Vice Chair, Bih-Yuan Ku, National Taipei University of Technology in Taiwan; Secretary, Lamont Ward, Long Island Rail Road; Papers Chair, Michel Thomet, Bechtel Civil Company; and Publicity Chair, Paul Flaherty, Goatlick Engineering, Ltd.

Papers of the 2005 Joint Rail Conference and previous year Joint Rail Conference can be purchased at ASME website http://www.asmeconferences.org/JRC05/index.cfm.

(Clockwise from upper left) Dave Tyrell of Volpe briefs the tour group in front of a test car at the TTCi facility; Luncheon audience listens to speaker George Binns, Chief of Inspections and Evaluation, Amtrak; Outgoing Chair Margaret Burnett transfers gavel to incoming Chair Denise Burleson; LTD 2005-2006 Executive Committee members gather during a session break



Trends in IEEE 802.11 WLANs

Ali Ghazizahedi, Cisco Systems, Inc, Xinrong Li, UNT, Kaveh Pahlavan, WPI

This paper provides an overview of the emerging WLAN applications in home networking, hotspot and corporate environments. The paper starts with an overview of the evolving markets. Then it provides a survey of related important standardisation activities, followed by how these technologies are incorporated into applications, and finally

it discusses the current technical challenges for WLAN security.

Introduction

The concept of wireless LAN (WLAN) was first introduced in late 1970's; the first serious commercial endeavor initiated in mid 1980's shortly after announcement of ISM bands in 1985 [1-3]; the first IEEE standard emerged after around one decade of committee work in 1997 [4]. Numerous innovative technologies and application scenarios were examined over the time [1-8], and in spite of all optimistic market predictions the first sizable market started to appear only in the recent years. This market has evolved in three branches, enterprise networks, home networks, and hot-spot access.

After proving themselves in vertical markets such as health care, education, and retail, WLAN is beginning to make inroads in general business-computing environments. According to a recent META Group study, 29% of 435 enterprises surveyed in the US had deployed WLAN as an adjunct to the campus network. Furthermore, an additional 44% indicated they would deploy WLAN within the next 24 months. To date, more than 25 million WLAN devices have been shipped worldwide and 741 models have been approved by Wi-Fi Alliance.

The WLAN is typically an extension of a wired Ethernet LAN. Ideally, this wireless extension should support the same functionality as the wired network, providing tight controls through rich feature sets, such as security, management, and quality of service (QoS). Enterprise WLAN must also scale from hundreds to thousands of devices. Viewing the WLAN as an extension of the wired LAN helps to simplify operations, management, and security

In addition to the traditional wireless data and voice applications, more recently indoor positioning is emerging as a new technology to be integrated into the existing local ad-hoc networks [9]. This technology is expected to help hospital personnel track in-demand equipment, help parents locate children, help family members and care-givers track special-need and elderly relatives away from supervision, and help public-safety and military units locate fire fighters and war fighters inside buildings during their missions.

Market Trends

The year 2003 was characterized by renewed enterprise adoption of the WLAN technology. The bulk of this growth continues to be driven by key vertical markets such as healthcare, retail, manufacturing, and education, all of which require networks that can provide the utmost flexibility in terms of connectivity and mobility. Furthermore, the growing trend toward embedding WLAN capability into mobile computing devices (laptop, PDA, cellular phone, etc.) will generate an enormous amount of demand from the client perspectives, which should help to speed continued infrastructure build-outs.

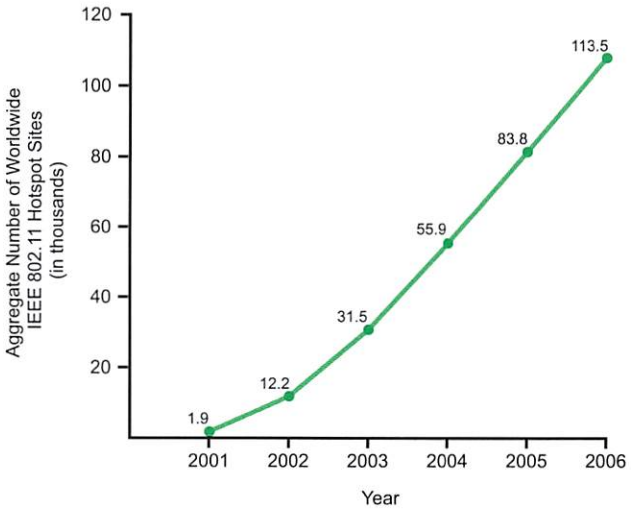
In 2003, total sales for WLAN equipment increased 41.1% year-over-year and it is estimated that the total WLAN market reaches to $3.7 billion by 2004 and $5.2 billion by 2008 [10]. Sales for SOHO (small office, home office)/home WLAN equipment in 2003 increased 66% comparing to 2002. Growth in this segment continues to be driven by aggressive pricing, strong sales of 802.11g devices, and, to a lesser extent, the introduction of multimedia devices for the home. It is estimated that this market will grow 62% in 2004 and reach nearly $2.7 billion and surpass the $3.8 billion mark by 2005 [10]. Similar patterns can be seen in EMEA (Europe, Middle East and Africa) but in Asia-Pacific area there was an increase in WLAN sales (25%) but decrease in the number of unit sold (6%) according to [11].

The year 2003 also marked the introduction of two new enterprise segments, WLAN switches/controllers and "light" access points. The demand for mobile voice technologies in the workplace is growing rapidly. Voice, as an application, is and will continue to drive the adoption of WLAN in the enterprise. In 2003 the market for Voice over WLAN phones grew 115% to $33 million. Moreover, it is estimated that this market will grow at a compound annual growth rate (CAGR) of nearly 30% over the next five years, as vertical markets such as healthcare, retail, manufacturing, and corporate enterprises continue to drive and speed the adoption of these devices [10].

The market for enterprise WLAN infrastructure grew nearly 20% in 2003 to $618 million and should surpass the $1 billion mark by 2007. Much of this growth will be driven by the growing number of large-scale WLAN deployments in the aforementioned vertical markets as well as increased adoption by the enterprise. Additionally, this market will also be fueled by sales of new classes of products including WLAN switches/controllers and "light" access points [9-11]. According to Infonetics Research, in the third quarter of 2003, enterprises made up 47% of worldwide WLAN hardware revenue, consumers made up 42%, and service providers (for hot-spot services) made up 11% [12]. And the enterprise proportion will show the most significant continued increase as enterprise-class switching and security systems drive adoption into this market.

Finally sales of SOHO/home client and infrastructure devices increased 43% and 91% respectively in 2003. It is predicted that going forward, growth of these devices should be slowed by initiatives such as Intel's Centrino and Intel's recent announcement that it intends to integrate access point functionality into PCs themselves [9].

Hotspots are locations that provide Internet access via WLAN. These are among the reasons that In-Stat/MDR expects WLAN hotspots to grow in number worldwide from 31,455 in 2003 to 113,555 in 2006 (see Fig.1), when worldwide user revenues will reach more than US$1.2 billion [13]. Another research firm, Gartner, predicts that there will be 70 million users of public hotspots by 2007 [14].



Source: In-Stat/VIDR, Scottsdale, Arizona, 2003

Figure 1. *Worldwide trends for Wi-Fi hot-spot growth*

Trends in Standards

The current and emerging important standardization activities related to WLAN are under either IEEE or Wi-Fi alliance. Table 1 and 2 summarizes these activities.

Table 1. Important WLAN Related IEEE Standards

802.11a	*It defines 54Mbps in the 5GHz band; low usage makes it least subject to interference.*
802.11b	*It defines 11Mbps bandwidth in the 2.4GHz band; it is the most widely deployed standard and, thus, is the most subject to interference.*
802.11g	*It defines 54Mbps bandwidth in the 2.4GHz band; it has wider range than 802.11a, but is also subject to 2.4GHz channel interference.*
802.11n	*It will support speeds of up to 108Mbps.*
802.11e	*It would add extensions to support QoS for voice applications, while retaining backwards compatibility with existing variants.*
802.15	*It is a low power solution with multi-month to multi-year battery life and very low complexity for applications such as sensors, interactive toys, smart badges, remote controls, and home automation. The 802.15.1 Bluetooth that operates in 2.4GHz band interferes with 802.11 2.4GHz devices.*
802.1X	*It defines port-based authentication in LAN environments; authentication credentials are never transmitted over wireless connections without encryption; EAP authentication types such as LEAP are components of 802.1X.*
802.11i	*It is draft security standard that defines AES encryption and EAP device authentication for 802.11 wireless networks.*

Table 2. Wi-Fi Alliance

Wi-Fi Protected Access	Interim technology to strengthen user and device authorization/authentication schemes prior to release of 802.11i standard. It includes support for 802.1X, EAP authentication, and TKIP encryption.
Wireless Multimedia Enhancements (WME)	Interim technology to synchronize client device and access points in terms of how to handle queuing, channel access and collision avoidance, so as not to configure devices specially to recognize VoIP phones and their traffic. WME uses four priority levels rather than eight as in 802.11e.

The WLAN standardization first started under IEEE 802.4L in late 1980's because 802.4 Token Ring was focused on manufacturing and the first dominant market perceived for WLAN was in the manufacturing floors. Soon after that IEEE 802.11 was formed to focus on WLAN. It took over a decade to finalize this standard for 1-2Mbps direct sequence, frequency hopping and infrared technologies in 1997 when the standard was already late [15]. The 802.11a was started soon after completion of the first standard. However, the 11Mbps B operating in 2.4GHz ISM bands emerged first and captured the developing markets soon. The 54Mbps A products operating in 5GHz bands appeared later and as of now it has been struggling in capturing a sizable portion of the emerging markets. Some experts believe that with the continued growth of 2.4GHz market and reduction of the cost and complexity of installation of WLAN access points, at certain point the interference in the 2.4GHz will develop a market for 5GHz products that enjoy larger number of non-overlapping channels. Meanwhile the 54Mbps G that is backward compatible with the B is replacing the B products.

Because of the progress in standardization, businesses are now evaluating running A and G WLAN, which each run at the speeds of 54Mbps, alongside 11Mbps B networks. The availability of all these WLAN types opens up new opportunities, as well as architectural and management considerations. For example, G is backward compatible with B, which is extremely desirable from a migration perspective, since G and B clients and access points can be mixed and matched. Still, if you deploy only B and G access points in a given coverage area (and no A), you remain limited to three non-overlapping channels. This could lead to interference. Also, G technology works such that once a B client associates with a G access point, G network throughput is impacted, even if the B client is not transmitting any packets. This is because special headers, which create network overhead, must be appended to G packets to enable B packets to detect and avoid G traffic.

Fortunately, tri-mode chipsets supporting B, A, and G recently began shipping, which means that decisions about which types of access points and clients to deploy will soon no longer be interdependent [16]. In other words, organizations could run any mix of B, A, and G access points that among them have as many as 27 non-overlapping channels (depending on imminent decisions about global cooperation on the use of the 5GHz spectrum) for easily configuring networks to avoid interference. Tri-mode clients supporting B, A, and G could simply associate with the best network connection available to them in a given location.

Interoperability of B products from different vendors is ensured by an independent organization called the Wireless Ethernet Compatibility Alliance (WECA), which identifies compliant products under its Wi-Fi Brand. With Wi-Fi membership boasting more than 140 companies, spanning component manufacturers, equipment vendors, and service providers, the future of the 802.11 standard is secured.

The 802.11n is another initiative in 802.11 to boost the performance to above 100Mbps. In 802.11n, nothing can be removed from 802.11 but only mechanisms that affect throughput hikes and from that perspective, backwards compatibility with both 2.4GHz G and 5GHz A must be maintained, with N itself likely to run in both bands. A final requirement, added by the task group itself rather than mandated in the charter, is that the N protocol will enable 100Mbps throughput modes within the existing 20MHz channels. This does not preclude even higher-throughput modes via the use of wider channels.

The other initiative is 802.11e. The original medium access control (MAC) protocol for WLAN does not support differentiation of traffic types or sources, making it unsuitable for applications where certain traffic needs to be prioritized, such as voice or video over IP. In 802.11's current state, there are two modes of communications, both of which will be enhanced in 802.11e. With DCF (distributed coordination function), based on 'listen before talk' technology, a wireless station waits for a quiet period on the network before transmitting data and detecting any collisions. An optional second mode PCF (point coordination function) goes a step further as it supports time sensitive traffic. It splits the time into contention-free and contention periods and transmits data during the former. However, while these two modes offer coordination and time sensitivity, neither distinguishes between different types of traffic.

The proposed 802.11e standard would add extensions to both modes to support QoS for voice applications, while

retaining backwards compatibility with the existing WLAN variants. The DCF would be enhanced with support for eight different traffic categories, with lower priority categories of traffic waiting for the others to go first, before accessing the medium. However, there are no guarantees of service, which could still limit the viability of heavy-duty voice over IP implementations.

The Related 802.15 WPAN Standard

The 802.15 WPAN is an initiative by the IEEE focused on developing a common set of standards for Wireless Personal Area Networks (WPAN) or short distance wireless networks. Established in January 1999, the WPAN working group, which is part of the Local and Metropolitan Area Network Standards Committee of IEEE, has since formed four task groups, each focused on necessary standards. The Bluetooth SIG (special interest group) specification serves as the foundation for developing the IEEE 802.15 WPAN standard, which would standardize the MAC and physical layers of Bluetooth. The Bluetooth SIG, established in 1998, made their specifications publicly available in the middle of 1999.

The idea behind 802.15 WPAN is to publish standards that allow devices such as PC, PDA, mobile phone, pager, and other handheld devices to communicate and interoperate with one another. The goal of publishing the 802.15 standards will be to accommodate wider adoption and applicability, and to deal with issues like coexistence and interoperability with IEEE 802.11 networks. The IEEE 802.15 working group defines three classes of WPAN characterized by data rate, power usage, and quality of service [4]:

IEEE 802.15.1 and Bluetooth—The 802.15.1 WPAN standard is based on Bluetooth version 1.1 specifications. While Bluetooth devices that are currently available are most likely to be v1.1, the Bluetooth standards body has pushed ahead of the 802.15.1 standard and developed a specification that should see devices being developed that offer data rates of about 10Mbps. Whilst the maximum range of Bluetooth v2.0 devices (currently 10-100m) is still being discussed the greater data rates means that Bluetooth is likely to be used both as a WPAN technology and as a WLAN technology that competes with 802.11b.

Table 3. General Differences between WLANs, WPANs, and LR-WPANs

	WLAN (802.11)	Bluetooth-based WPAN (802.15.1)	Low-rate WPAN (802.15.4)
Range	*~100 m*	*~10 - 100 m*	*~10 m up to 75m*
Data throughput	*~2 - 11 Mb*	*~1 Mbs*	*~0.25 Mbs*
Power consumption	*medium*	*low*	*ultra-low*
Size	*larger*	*smaller*	*smallest*
Cost/complexity	*>6*	*1*	*0.2*

IEEE 802.15.2—This is a standard focused on recommended practices for coexistence between WPAN and WLAN. This standard is yet to be ratified.

IEEE 802.15.3—The 802.15.3 working group has been tasked with developing a high data rate (up to 55Mbps) WPAN technology capable of handling multimedia content. This technology has been designed to offer QoS meaning that data such as video should be delivered between devices with no break down in quality of picture. This draft standard is yet to be ratified and as such no devices with 802.15.3 connectivity are currently available.

IEEE 802.15.3a and Ultra Wide Band (UWB)—UWB is being considered by the IEEE as the 802.15.3a standard. This technology is a short-range technology (up to 10m) with high data rates (planned data rates of about 400Mbps) for applications which involve imaging and multimedia. Currently two industrial alliances, led by Motorola and Intel, respectively, are working on two different technologies for UWB, that is, DS-UWB and Multiband OFDM technologies.

IEEE 802.15.4 and Zigbee—The Zigbee standard has now been endorsed by the IEEE as the official 802.15.4 standard. This is a WPAN technology developed by an alliance of companies with the aim of producing a low power consumption and low cost WPAN technology that could be included in a range of low data rate devices such as mouse, keyboard, joystick and educational games platforms. The data transfer rates of Zigbee depends on the frequency used (250Kbps at 2.4GHz, 40Kbps at 915MHz and 20Kbps at 868MHz) and the range of Zigbee can go up to 75m depending on a number of factors including the power used.

Table 3 compares range, data throughput, power consumption, size and complexity of 802.11, 802.15.1 and 802.15.4.

Technology Trends for Emerging Applications

In response to the fast increasing demands for WLAN, manufacturers in this industry are clearly tailoring their products to different application sectors, that is, home networks, enterprise networks, and hot-spot access. The technologies applied to these applications have evolved through different paths with different mentalities. In the following three sections we provide specifics of the technologies used for these three application sectors.

Home Networking Alternatives

Several technologies have been examined for wireless home networking applications. One of the early solutions was the HomeRF technology, the next competitor was the Bluetooth technology, and IEEE 802.11b WLAN finally captured the current market. The newer 802.11g is replacing 802.11b devices. HomeRF and Bluetooth technologies were under WPAN activities that are currently under 802.15. Table 4 compares the feature of these four technologies.

It should be noted that the maximum number of devices supported by each standard depends on data rate per device, and 40- to 128-bit RC4 refers to very robust data security algorithms.

Table 4. A Brief Comparison of HomeRF, Bluetooth, and 802.11 WLAN Standards

	HomeRF	Bluetooth	802.11b	802.11g
Date Rates	1 or 2 Mbps	1Mbps	11Mbps	54Mbps
Max # Devices	Up to 127	Up to 26	Up to 26	Up to 26
Security	Blowfish	0-, 40-, and 64-bit	40- to 128-bit RC4	WEP
Range	150 ft	30 to 300 ft	150 ft indoors, 300 ft outdoors	150 ft indoors, 300 ft outdoors

Technologies for Hot-spot

WLAN hotspots are essentially 802.11-based IP networks and based on this fact, use of core protocols developed in the IEEE (such as 802.1X) and the Internet Engineering Task Force (IETF) are prevalent [17]. Usually the visited hotspot accommodates a variety of credential types (e.g., user-

name/password, Subscriber Identity Module (SIM), and X.509 certificates). In a subscription-based access model, it must be possible to provide end-to-end security for authentication and authorization. It is desirable for different users to avail of different levels of service depending on whether they are in the home provider's network or in a visited network.

Another issue is secure key distribution. Current standards for WLAN key distribution do not fully meet this requirement in roaming scenarios but it is desirable that key distribution between home providers and visited networks for wireless link layer encryption should be secured and cryptographically bound to authentication and session information.

Other concerns about hot-spots are re-authentication and protocol translation. When moving between access points managed by the same network, operator must not cause significant delay and must not require user interaction. If protocol translations are required to be integrated with legacy or proprietary authentication back-ends, such translations should occur within the premises of the legacy network.

In the situations where the integration of services requires inter-working with another network (such as a cellular operator's core data network), it is recommended to have "loose coupling" between the WLAN hotspot and core networks. In other words, WLAN networks should be seen as standalone networks based on IEEE and IETF core protocols as opposed to radio access networks, and should not require the use of domain-specific mobility management protocols over the client's WLAN interface (for example, GPRS Mobility Management or GMM) [18].

Enterprise WLAN Technologies

The WLAN access points designed for consumer market for home networking are not deployable in enterprise environment due to its lack of security, scalability, manageability among many other features critical to enterprise applications.

Currently there are two competing technologies in designing enterprise-class WLAN access points. One is the so-called fat-AP solution. With such technology, the AP for enterprise application is an enhanced version of the one for home application. All the features critical to enterprise applications are integrated into the AP, which makes it fatter as compared to the AP designed for home applications. The fat-AP solution has some serious shortcomings. For example, as the WLAN in cooperate campus grows, maintaining and managing larger number of AP's over large area become a challenging issue. Such a solution also lacks scalability and flexibility in system upgrade and capacity expansion. The fat-AP architecture concentrates all of the WLAN intelligence in the AP. This is the most common AP architecture used today, where AP handles the RF communication, as well as authenticating users, encrypting communications, secure roaming, WLAN management, and in some cases, network routing. Towards solving the problems faced by fat-AP technology, most recently a thin-AP solution has entered into the market [19,20]. Strongly backed by several companies, a lightweight-AP protocol (LWAPP) has been submitted to IETF for standardization for the thin-AP solution. With thin-AP solution, WLAN AP functionalities are carefully divided and a portion is moved from AP to a WLAN access controller which conveniently provides a centralized management and maintenance point for the whole enterprise WLAN network. The thin-AP architecture actually uses two components—an AP that's essentially a stripped down radio and a centralized management controller that handles the other WLAN system functions. Wired network switches are also required. By centralizing the configuration and management of the AP's, this architecture greatly simplifies the management of hundreds of AP's.

A variation of the thin-AP is one that's often described as a "fit-AP." In this architecture, the AP is slightly beefier than just an RF radio, the network switches are optimized for both wireless and wired environments and the central control point is also present. The AP handles the RF and encryption, while the network switches, because they are aware of the wireless users' identities and locations, handle secure roaming, quality of service, and certain aspects of user authentication. The central management controller also handles AP configuration and management.

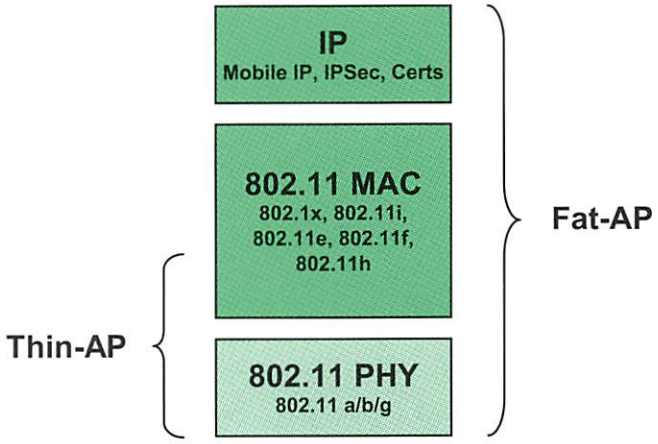


Figure 2. *Fat and thin Access Point components*

With such a new architecture, many novel applications can be conveniently implemented for the enterprise WLAN networks—including centralised traffic monitoring and location tracking of mobile users for security and performance optimization purposes; centralised RF management, such as dynamic channel assignment and power control, to optimise the coverage and throughput of the wireless network.

The major benefit of using thin-AP vs. fat-AP is scalability and cost. Thin-AP minimizes the intelligence in the AP. With this approach, relatively simple AP's can share the features that enhance wireless communications in a cost-effective and efficient manner. For a small WLAN, with fewer than 10 AP's which is usually deployed for a small business or a workgroup in a larger corporation, the fat-AP architecture—or the traditional approach—may be more cost-effective. However, as the WLAN grows, the thin- or fit-AP architectures, which offer greater manageability and centralized control, will be the approach that most enterprises will adopt [21,22].

Trends in WLAN Security

Security is one of the leading concerns of the WLAN industry. While home networking and hot-spot users are also interested in better security, the enterprise application users are leading serious investigation to improve the existing security measures. Recent security advances such as Wi-Fi Protected Access (WPA) product compliance and interoperability certification mean that dynamic encryption keys, 802.1X authentication, and other important security capabilities have been added to Wi-Fi products for standards-

based security. WPA is a subset of the forthcoming IEEE 802.11i standard for stronger security than was offered in 802.11's initial Wired Equivalent Privacy (WEP) algorithm, which relies on static encryption keys. While vendors took it upon themselves to plug the security holes with robust solutions of their own, the additional availability of standards-based technology allows interoperability among different vendors' clients and access points.

In addition, many vendors are adding automated capabilities to detect security policy violations, to log and track user connections, and to authenticate users based on their personal identity, rather than only on a MAC or IP address. This action is important, given that small devices can easily be lost or stolen, opening up potential access opportunities to outsiders.

The authentication of both users and networks is a critical component of wireless LAN security. However, unlike data encryption (the other major component of wireless network security) authentication was not specified in the original 802.11 wireless LAN standards. As a result, the wireless industry has rallied around a protocol called 802.1X as a standard authentication framework for 802.11 LANs.

The IEEE 802.11 Task Group I, for example, is drafting amendments to the 802.11 specifications to include 802.1X. Some vendors have implemented 802.1X and compatible authentication algorithms in their products. These algorithms are based on the Extensible Authentication Protocol (EAP), which is specified in IETF RFC 2284.

In the next two sections, we will elaborate on importance of EAP and 802.1X for security and also challenges facing enterprise customers for providing connectivity between WLAN and wired network.

EAP

EAP was originally created for use with PPP (point-to-point protocol)-based WAN (wide-area networks) such as dial-up networks. There are now many derivatives of EAP for use in 802.11 and other LANs. The 802.1X standard leaves the choice of the algorithm up to the network implementer.

Why are there so many EAP? Two variations are EAP Wireless and EAP-TLS (transport layer security). In addition, products will eventually support an emerging algorithm called Protected EAP (PEAP), currently an Internet draft protocol. Similarly, Microsoft, in the newer versions of its operating systems, supports 802.1X and EAP-TLS and has announced plans to support PEAP.

EAP-TLS uses digital certificates instead of usernames and passwords to fulfill the mutual challenge. When a client requests access, the response from the authentication server is a server certificate. The client has a certificate, signed by an in-house or third party certificate authority that has been preconfigured by the network administrator. The client will reply to the authentication server's challenge with its own certificate, rather than with a password. Using its digital certificate, the client also validates the server certificate. Based on the certificate values, the EAP-TLS algorithm can derive dynamic WEP keys, and the authentication server will send the client the WEP key for use during that session.

Certificate-based algorithms like EAP-TLS are highly secure, as it is nearly impossible to forge a certificate digitally signed by a certificate authority. On the other hand, the management of certificates can be more complex and expensive than username/password-based authentication.

In PEAP, the conversation between the EAP peer and the backend server is encrypted, and integrity is protected within a TLS channel. Mutual authentication is required between the EAP peer and the backend server. The client uses EAP-TLS to validate the server and create a TLS-encrypted channel between client and server. The client uses some other EAP mechanisms, such as Microsoft Challenge Authentication Protocol (MSCHAP) version 2, over this encrypted channel to enable server validation. Because the challenge/response packets are sent over a TLS encrypted channel, the password and the key are not exposed to offline dictionary attacks.

What is 802.1X?

802.1X is a port-level access control protocol that sits between one of any number of optional authentication algorithms and an underlying LAN. It is not an authentication algorithm itself. Rather, it translates messages from an authentication algorithm into the appropriate frame formats of the LAN access types. The LAN type pertinent to this discussion is 802.11, but 802.1X can also be used as the authentication method for other 802-based LANs, including 802.3 Ethernet or 802.5 Token Ring networks.

802.1X leaves both the choice of authentication algorithm and key management method up to each EAP authentication type. Specifically, a piece of the 802.1X protocol called PAE (port authentication entity) runs on the three components of a secure wireless network system: the client device, the access point (AP), and the back-end authentication server such as a RADIUS (remote authentication dial-in user service) server.

In 802.1X terminology, when the PAE is functioning on the client device being authenticated, it is called the supplicant. The PAE function on the AP is called the authenticator, and the software on the back-end server is called the authentication server. The authentication server must support the same EAP authentication algorithm in use by the client.

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Gaspar Messina

Readers will be sorry to hear of the death, on 4th June 2005, of VTS News Senior Editor Gaspar Messina. Gaspar was a very long-standing contributor to the society, both as Chapters Co-ordinator, a position he held until the month before his death when it was reorganised into a newly reorganized Membership Development Committee that includes chapter relations and distinguished lecturer coordination, and as Senior Editor responsible for Chapter News and Meetings. He took up his position on the VTS News in November 1982, taking over from then Vice-President Sam McConoughey. At that time VTS had 25 chapters, and in his first column he 'hoped to see a flurry of Meeting Reports and Election Results sent to the Chapters Activities Chairman'. Unfortunately that never appeared to the degree that he would have liked, and Gaspar was frequently chasing people for reports for his column. He will be missed.

VTC2005-Spring in Stockholm

A highly successful VTC2005-Spring attracted almost 800 attendees to Stockholm at the end of May. 659 papers were presented, along with panels and plenary presentations, and delegates were hosted by the Mayor of Stockholm for a reception at the City Hall on the first night. A full report on the conference will appear in the next VTS News.

VTC2005-Fall in Dallas

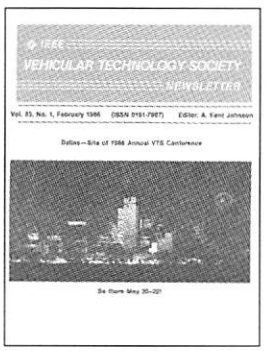
NextGen Networks and Services through Broadband Wireless

Preparations are well in hand for the 62nd VTC, VTC2005-Fall, which will be held in Dallas at the Intercontinental Hotel in suburban Addison September 25-28. Registration is available at its Website at http://www.vtc2005fall.org. Advanced registration closes on **5 September 2005**.

The conference will focus on wireless and mobility technologies enabling people at all global sites to work, commute, telecommute and communicate efficiently and profitably.

Photo Dallas Area Rapid Transit

Downtown Dallas



VTS News February 1986

The conference will vary from the normal pattern by starting each day with a plenary keynote. In addition, there will be an awards luncheon, poster sessions, exhibits, tutorials and much more. A complete list of events is at http://www.vtc2005fall.org.

The theme of the conference is "NextGen Networks and Services through Broadband Wireless". It is anticipated that 750 participants from around the world will be presenting both technical and applications-based papers in more than 15 speciality areas of wireless communications.

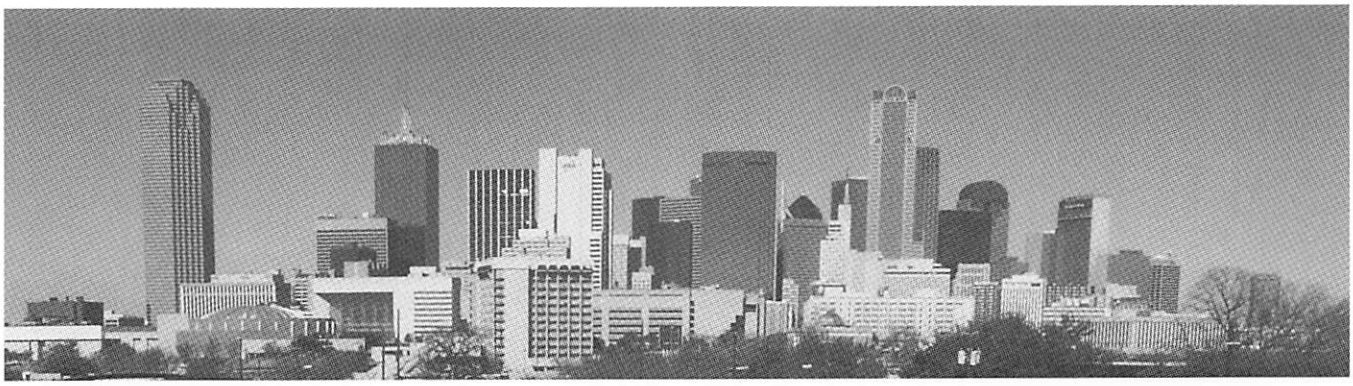
Robert Shapiro, P.E., SMIEEE, general chair of the conference said, "The programming for this conference is deeply integrated in our mission to nurture the 'global village' of the 21st century."

Dallas last hosted VTC in 1986, and the city recently played host to Globecomm. Mr. Shapiro said, "Dallas has been the location of the most successful conferences of the IEEE Technical Societies largely because of the quality of the program but also the outstanding support that local industry has always provided to our conferences. Local companies have encouraged their engineers to participate as volunteers, attendees, and paper contributors. The conferences have also benefited from the monetary support contributed by these companies as Patrons of the conference."

As the telecom sector went through the chaotic turmoil of the past few years, support for external activities, such as conferences and technical/professional societies, declined significantly. "Now, however, as the business recovery phase is developing, it is important that our technical staffs are equipped to competitively address the new technologies and services," Mr. Shapiro said.

Plenary Speakers

As noted above, the conference will start each day with a plenary keynote. Speakers include Alan Gatherer, Chief Technical Officer Communications Infrastructure of Texas Instruments; Dr. Young Kyun Kim, Senior Vice President of Global Standards & Research for Samsung Electronics; and Professor Jerry D. Gibson of the University of California, Santa Barbara. Professor Gibson will be giving a talk on 'Wide Open Spaces, or, Mostly Wireless, Most of the Time'. Communications networks are becoming less homogeneous, less structured, and less reliant on wires than ever. It is expected that, in addition to digital cellular links, the wired public switched telephone network (PSTN), the wire-



line packet switched network, and wireless local area networks (WLANs), future networks will also include mobile ad hoc networks and mesh networks of WLAN access points. In fact, there will be a proliferation of these WLAN access points, and multihop wireless links will be dominant. This talk addresses the challenges and opportunities as we enter the true next generation where our communications services traverse these 'mostly wireless, most of the time' networks, not just from the point of view of the access network, but also in the way media content is consumed by the user via handheld devices, which will be quite different from today.

Dr. Young Kyun Kim will give a talk entitled 'Beyond 3G Roadmap and Emerging Technologies'. As we are getting experienced using mobile handsets in our daily lives, we are living in a convergence period with mobile communication, internet, computing and broadcasting. Beyond 3G technology can be approached either by cellular-based, 2G, 3G and beyond 3G or nomadic-based, IEEE 802.11 (W-LAN), 802.16d (WiMAX) and 802.16e (WiBro). Research and business interest in future 4G mobile systems is increasing globally and extensive research is progressing through WWRF and many national 4G research fora. New services and applications are crucial for differentiating 4G from 3G. For future advanced high-speed multimedia services and applications, more IP-centric, simplified network architectures are essential to reduce the infra cost and fast connection time that users want. In Korea, IEEE-802.16e –based Wireless Broadband (WiBro) service will start commercially in 2006 and key requirements and network architectures are introduced in this presentation.

Photo Dallas Area Rapid Transit

Hyatt Regency Tower with a TRE train in the foreground

Tutorials

Seven tutorials will be presented. Further details can be found at http://www.vtc2005fall.com

T1: All-IP Mobile Networks

David Wisely

This course sets out to understand exactly what an "all-IP" network really is, shows how existing networks fail to qualify for this term and discusses the potential of such networks. The course looks at the key IP technologies for all-IP mobile networks: Mobility (including Mobile IP), Quality of Service, "call" control (using Session Initiation Protocol – SIP) and security. The commercial aspects of all-IP mobile networks is tackled – looking at the British Telecom 21st Century network and other business models.

T2: QoS and Scheduling in Wireless Networks

Vijay G. Subramanian

This tutorial is intended to provide an overview of the state of the art for the theory of wireless scheduling. Along the course specific examples from real technologies will be provided to showcase the applicability of the developed theory.

T3: Spatial Channel Models for MIMO Applications in Modern Wireless Communications

Aris Moustakas

In this tutorial, after introducing the basic concepts and requirements of channel modeling, we describe a number of channel models introduced in standards bodies (3GPP/3GPP2, IEEE 802.xx) for various environments. It compares these models with measurement results and discuss the complexity aspects of the various approaches of channel modeling.

T4 Low-Density Parity-Check (LDPC) Codes

Gerhard Kramer and Alexei Ashikhmin

The aim of this half-day tutorial is to give the participants a basic understanding of low-density parity-check (LDPC) codes, and their analysis and design.

T5: Principles of Space-Time Coding and Signal Processing

Hesham El Gamal

Photo Dallas Area Rapid Transit

Crossing the DART tracks in the West End with an older form of traction

This tutorial gives a comprehensive treatment of space-time coding/decoding under different channel state information (CSI) and feedback assumptions. We provide a unified treatment of the different design approaches proposed in the literature. It will strive for the optimal balance between theoretical rigor and practical utility.

T6: Cooperative Wireless Communications

Elza Erkip

The broadcast nature of wireless communications suggests that a source signal transmitted towards the destination can be overheard at neighboring nodes. Cooperative communications refers to processing of this overheard information at the surrounding nodes and retransmission towards the destination to create spatial diversity, thereby to obtain higher throughput and reliability. This tutorial provides a comprehensive overview of the theory of cooperative communications and its practical aspects.

T7: Adaptive OFDM versus MC-CDMA for next-generation wireless systems

Lajos Hanzo

This tutorial is in two parts: a morning session consisting of an introduction to OFDM/MC-CDMA, and then the afternoon session covering advanced OFDM/MC-CDMA research: Adaptive versus Space-time Coded OFDM/MC-CDMA; PIC-assisted channel estimation for SDMA-aided multiuser OFDM; and Multiuser detection for MC-CDMA.

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	
29 May – 1 June 2005	VTC 2005-Spring	Stockholm, Sweden	http://www.vtc2005spring.org	
6–8 June 2005	IV'05	Las Vegas, NV	http://www.ieeeiv.org	
19–22 June 2005	IST Mobile & Wireless Summit	Dresden, Germany	http://www.mobilesummit2005.org	
5–8 July 2005	AP/URSI '05	Washington, DC	http://apsursi2005.org/	
25–27 July 2005	Electric Ship Technologies Symposium 2005	Philadelphia, PA	http://ewh.ieee.org/conf/ests05/	
4–5 August 2005	2nd Asia-Pacific Wireless Communications Symposium	Sapporo, Japan	http://www.ieee-jp.org/jc/chapter/vts/vt.htm	
5–7 September 2005	ISWCS 2005	Siena, Italy	http://www.iswcs.org	
11–15 September 2005	PIMRC 2005	Berlin, Germany	http://www.pimrc2005.de	
13–16 September 2005	ITSC 2005	Vienna, Austria	http://www.itsc2005.at	
19–21 September 2005	MWCN 2005	Marrakesh, Morocco	http://www.ctr.kcl.ac.uk/MWCN2005/	
26–29 September 2005	VTC 2005-Fall	Dallas, TX	http://www.vtc2005fall.org	
15–17 October 2005	VES'05	Xi'an, Shanxi, China	https://150.135.155.192/ves05/index.php	✓
28 November – 2 December 2005	Globecomm 2005	St. Louis, MO	http://www.ieee-globecom.org/2005/	
13–15 February 2006	3rd European Workshop on Wireless Sensor Networks	Zurich, Switzerland	http:// www.ewsn.org	✓
2–5 April 2006	European Wireless 2006	Athens, Greece	http://www.telecom.ece.ntua.gr/EW2006/	✓
8–10 May 2006	VTC 2006 Spring	Melbourne, Australia	http://www.vtc2006spring.org	✓
9–12 May 2006	ICT2006	Madeira, Portugal	http://www.ict2006.org	✓
4–5 June 2006	IST Mobile & Wireless Summit	Myconos, Greece	http://www.mobilesummit2006.org/	
17–20 September 2006	ITSC 2006	Toronto, Canada	http://www.ewh.ieee.org/tc/its/itsc2006/	
25–28 September 2006	VTC2006-Fall	Montréal, Canada	http://www.vtc2006fall.org	
22–25 April 2007	VTC2007-Spring	Dublin, Ireland	http://www.vtc.org	

Conferences marked '✓' have open calls for papers as of 1 March 2005. 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.

VTC2006-Spring MELBOURNE

Delivering the Promise of 3G

CALL FOR PAPERS

The 63rd IEEE Vehicular Technology Conference 7-10 May 2006

The 63rd IEEE Vehicular Technology Conference (VTC) will be held at the Grand Hyatt Melbourne, Melbourne, Australia, 7-10 May 2006. As the first ever VTC to be held in the southern hemisphere, the 63rd VTC (VTC 2006-Spring) will feature world-class technical sessions and tutorials on, but not limited to, the following topics:

1. Antenna systems, antenna arrays, and channel measurements and characterization.
2. Signal transmission and reception, signal processing, transceiver design, and air interfaces
3. Multiple antenna systems
4. Ultra wideband systems
5. Future wireless communications systems, and their inter-working and convergence.
6. Spectrum efficiency, network capacity, and cognitive radio
7. Radio resource management and wireless quality of service (QoS)
8. Mobile ad hoc networks, mesh networks, and sensor networks
9. Mobility and location management and the related services
10. Mobile internet and all-IP networks
11. Cross-layer design of wireless systems
12. Mobile satellite systems
13. Ambient wireless networks
14. Vehicular electronics
15. Intelligent transportation systems
16. Rail signals, communications, and control

Prospective authors are invited to submit either *2-page summaries* or preferably *5-page full papers* electronically via the conference web page (www.vtc2006spring.org) or direct to vtc06s.trackchair.org

Important Deadlines:-

Submission due:	16 September 2005
Author notification:	12 December 2005
Camera ready papers due:	11 February 2006

IEEE VTS *Connecting the Mobile World*

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