probability of other call type(s) is equal to its maximum acceptable value is less than the optimal case. Thus, if it exists, there is a unique maximum for the system capacity (remember that it depends on the QoS constraints and system characteristics); and because of the traffic order [3], there is a unique prioritisation order. MFCR can achieve capacity maximisation since the numbers of reserved channels can be finely adjusted by fractions of one.

Results: A cellular system with two services is assumed and the performance of four strategies is compared; the non priority scheme (NPS), the CR, the FCR, and the MFRC. The CR (FCR) scheme is used to prioritise new and handoff calls with service 2, referred to as CR-2 (FCR-2), and to prioritise handoff calls of both services, referred to as CR-H (FCR-H). The values of the different parameters involved in the numerical evaluations are $N_c = 40$, $b_1 = 1$, $b_2 = 2$, $p_1 = 1/180s$, $p_2 = 1/300s$, $q_1 = 1/900s$, $q_2 = 1/1000s$, $f_1 = 0.8$, and $f_2 = 0.2$. The QoS constraints to be met are $P_{DR} \leq 0.02$, $P_{DL} \leq 0.02$, $P_{DR} \leq 0.002$, and $P_{DL} \leq 0.002$.

Fig. 1 shows the offered traffic for which all the QoS constraints are satisfied in the different CR strategies against the number of reserved channels. Note that the performance of CR-2 and CR-H can be derived from these representing FCR-H and FCR-2, respectively. For the MFRC strategy, it was found that, with the specified QoS constraints, the algorithm to determine the optimum numbers of reserved channels converges when the prioritisation order is $N$-H-H2-H2. If such order is used, the MFRC strategy achieves maximum capacity. Fig. 1 shows the cell capacity for the MFRC strategy for two cases: (i) against $R_1$ when $R_2 = 1.19897$ and $R_1 = R_3 + 1$, and (ii) against $R_2$ when $R_3 = 0.7934$ and $R_1 = 1.7934$. The numbers of reserved channels were deliberately chosen to show the optimum capacity point in the graphs. As it is observed, the MFRC strategy achieves 12.31% capacity gain relative to the prioritisation schemes.

Conclusions: A multichannel reservation strategy to achieve maximum capacity in multi-service mobile cellular networks is presented. We noticed that the process of selecting the right prioritisation order is not trivial and that only one prioritisation order allows us to achieve maximum capacity. An algorithm to determine the optimum numbers of reserved channels was also proposed.

References

Multirate SIC receiver for UMTS

1. Barbancho, A.M. Barbancho and L.J. Tardon

A multirate successive interference cancellation (MSIC) receiver for UMTS uplink is presented. This receiver takes into account the multirate nature of the UMTS signal based on variable length codes to select the strongest user, which is detected and cancelled. The proposed scheme outperforms other commonly employed receivers such as the minimum mean squared error receiver and the correlator receiver.

Introduction: One commonly employed multiuser detector is the successive interference cancellation (SIC) receiver [1]. The SIC receiver is based on the iterative detection and cancellation of users in order from the strongest to the weakest. The ranking of the users according to their received powers is quite simple in single-rate systems or in systems in which the multirate is achieved by means of multicode. The problem becomes more difficult when variable length codes are considered, as in UMTS. Though some multirate SIC (MSIC) receivers for variable length codes have been implemented, they are only suitable for dual-rate systems with a single spreading code [2]. These receivers cannot be directly applied to UMTS signals because in UTRA FDD uplink every physical channel is made up of two-layered spreading codes, the multirate is achieved by means of variable length codes and there are multiple user data rates. Therefore, a more specific SIC receiver should be implemented.

In this Letter, an SIC receiver specially designed for the UMTS signal is presented. The described MSIC receiver is a one-stage SIC and it is analysed for a synchronous scenario, but it can be easily extended to the multistage [3] and asynchronous case.

System model: The spreading applied to the UMTS physical channels consists of two operations: channelisation and scrambling [4]. During the channelisation operation, orthogonal variable spreading factor (OVSF) codes (employed as short codes) are used to transform the data symbols into a number of chips. The number of chips per data symbol transmitted in a certain channel $k$ is called the spreading factor $S_k$ which depends on the channel's symbol rate. In the second operation, a scrambling code is applied to the spread signal. The length of the scrambling code $(N)$ is the same for all channels. The scrambling code is used as a long code and it lasts $M_k$ data symbols (where $M_k = N/S_k$ is an integer number). Therefore, adding additive white Gaussian noise (AWGN) noise, synchronous users and considering control channels (DPDCH) and data channels (DPDCH separately, the received UMTS baseband signal can be expressed as follows:

$$r(t) = \sum_{k=1}^{K} \sum_{i=0}^{M_k-1} A_k(i) h_k(i,j_k) x_k(t - j_k T_k - iT) \times s_k(t - iT) + n(t)$$

where $K$ is the number of active channels; $h_k(i,j_k)$ is the $i$th bit transmitted in the $k$th channel during the interval $[iT, (i+1)T)$; $A_k(i)$ is the amplitude of the $k$th user's signal, $c_k(t)$ is the channelisation code of length $S_k$ chips; $T_k$ is the $k$th channel's data symbol; $s_k(t)$ is the scrambling code of length $N$ chips; $n(t)$ is the AWGN noise with unit power spectral density; and $i$ is the number of scrambling code period.

Fig. 1 System capacity in Erlangs/cell for different CR strategies

Conclusions: A multichannel reservation strategy to achieve maximum capacity in multi-service mobile cellular networks is presented. We noticed that the process of selecting the right prioritisation order is not trivial and that only one prioritisation order allows us to achieve maximum capacity. An algorithm to determine the optimum numbers of reserved channels was also proposed.

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H. Heredia-Ureta and F.A. Cruz-Pérez (Communication Section, CINVESTAV-IPN, Av. IPN 2508, Col. San Pedro Zacatenco, C.P. 07360, Mexico City, Mexico) E-mail: facruz@mail.cinvestav.mx
L. Ortigosa-Guerrero (WFI, 4810 Eastgate Mall, San Diego, CA, 92121, USA)
Multirate SIC: The MSIC receiver scheme is shown in Fig. 1. For each channel $k$, the scrambling code is removed and the signal goes through the filters matched to the different OVSF codes. The output of each matched filter is then sampled at the symbol rate $T_s$ of its corresponding channel. In a conventional SIC receiver, where all users transmit with the same data rate, these outputs can be directly employed to compare the signal strength of the channels. However, in this scenario, each channel can have a different symbol rate, therefore a different method to compare the energy of the received channels must be proposed. Note that, though the symbol rate is different, the scrambling code period $T_s$ is the same for all users, therefore this period is a good choice to perform the comparison. Therefore, the outputs of the $K$ matched filters are stored during a scrambling code period. The matched filter outputs corresponding to a certain user $k$ are arranged to form the vector:

$$y_k(i) = [y_k(i, 0), \ldots, y_k(i, M_k - 1)]$$  \hspace{1cm} (2)

This means that the energy per bit of users 1, 2 and 3 is 15, 10 and 5 dB larger than the energy per bit of user 4 [5]. Fig. 3 shows the BER attained for the DPDCH of user 4, for a fixed $E_b/N_0$ ratio of 10 dB, against the power ratio. The power ratio is defined by $PR = 10 \log_{10}(E_b/N_0) \text{ dB}$ for $i = (1, 2, 3)$ with $E_1 = E_2 = E_3$. In both figures, it can be noticed that the MSIC receiver achieves better BER results than the MMSE and the correlation receivers. Even more, in the simulated scenarios, the BER attained by the MSIC receiver is below the target BER in UMTS, whereas the detection with the correlation receiver or the adaptive MMSE receiver renders unreliable.

![Fig. 1 Block diagram of MSIC receiver](image)

The energy of each channel $k$ during a whole scrambling code period $i$ is then estimated according to (3):

$$P_k(i) = \sum_{j=0}^{M_k-1} |y_k(i, j)|^2$$  \hspace{1cm} (3)

The $M_k$ bits transmitted during the interval $(iT_s, (i + 1)T_s)$ by the user with maximum energy (3), are detected:

$$b_k(i) = [b_k(i, 0), \ldots, b_k(i, M_k - 1)]$$  \hspace{1cm} (4)

Finally, the amplitude of the detected user is estimated according to (5), to regenerate the detected signal and to cancel it from the received baseband signal:

$$d_k(i) = \frac{\sum_{j=0}^{M_k-1} b_k(i, j)h}{M_k}$$  \hspace{1cm} (5)

It must be noted that the proposed MSIC receiver is specially suited in case the short scrambling sequences of length 256 chips are chosen for the uplink. This is, in fact, the normal case when a multiuser receiver is employed at the base station. If the long scrambling codes were chosen, the MSIC could be directly employed using, instead of the scrambling code period, the least common multiple of the length of the channelisation codes.

**Simulation results:** The performance of the MSIC detector is compared against the performance of the correlation receiver and the MMSE receiver. In the simulations, four UMTS users are considered. Each user transmits both a DPCCH and a DPDCH. The DPCCHs have $SF=256$ and the DPDCHs have spreading factors $SF_1=128$, $SF_2=64$, $SF_3=32$, $SF_4=64$. Fig. 2 shows the BER attained for the DPDCH of user 4 against $E_b/N_0$ ($E_b$ is the energy per bit and $N_0$ is the one-sided noise power spectral density of the AWGN noise). The simulated power profile is $PP=[15, 10, 5, 0]$ dB.

![Fig. 2 BER for user 4 against $E_b/N_0$ with $PP=[15, 10, 5, 0]$ dB](image)

**Conclusions:** A multirate SIC receiver specially designed for UMTS-FDD uplink has been presented. The MSIC receiver takes into account the multirate nature of the UMTS signal in order to determine the strongest user to be detected and cancelled. The receiver outperforms other very commonly employed receivers such as the correlation receiver and the MMSE receiver.

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1. Barbancho, A.M. Barbancho and L.J. Tardón (Departamento de Ingeniería de Comunicaciones, ETS Ingeniería de Telecomunicación, Universidad de Málaga. Campus Universitario de Teatinos s/n. 29071 Málaga, Spain)
E-mail: ibp@ic.uma.es
One-year cloud attenuation results at 50 GHz

K. Al-Ansari, P. Garcia, J.M. Riera and A. Benarroch

Introduction: Precipitation effects are known to be the main impairment for millimetre-wave signals propagating through the atmosphere. But cloud attenuation, which may cause deep fades in this band, represents an important factor in designing attenuation margins for slant-path links owing to its higher probability of occurrence.

The Radiocommunication Group of the Polytechnic University of Madrid has carried out a propagation experiment using the 50 GHz ITALSAT beacon signal. The constructed receiver has a 1.2 m antenna, viewing the satellite at a 40° elevation. Details of the receiver and auxiliary equipment can be found in [1]. Standard meteorological data (radio sounding and synoptic) have been used for the analysis.

In this Letter, one-year results for cloud attenuation, including the comparison of experimental distributions with model predictions [2-6], are presented and discussed.

Synoptic data statistics: Monthly and yearly cloud cover percentages for the measurement period (2000) are presented in Table 1. These values are derived from synoptic data, by applying the Warren method [7] and adding up the number of octants for each type of cloud at 0, 6, 12 and 18 h UTC. Four types of low cloud are considered, according to the recent attenuation model proposed by Dissanayake, Allnutt and Haidar (DAH) [4]: cumulonimbus (Cb), cumulus (Cu), nimbostratus (Ns) and stratus/stratocumulus (St/Sc).

Table 1: Frequency of occurrence (%) for low cloud types and total (all cloud types included)

<table>
<thead>
<tr>
<th>Month</th>
<th>Cb (%)</th>
<th>Cu (%)</th>
<th>Ns (%)</th>
<th>St/Sc (%)</th>
<th>Total (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>January</td>
<td>0</td>
<td>0.61</td>
<td>4.75</td>
<td>15</td>
<td>24.70</td>
</tr>
<tr>
<td>February</td>
<td>0</td>
<td>0.82</td>
<td>0</td>
<td>12.40</td>
<td>29.12</td>
</tr>
<tr>
<td>March</td>
<td>0.22</td>
<td>1.67</td>
<td>15.50</td>
<td>37.50</td>
<td>24.70</td>
</tr>
<tr>
<td>April</td>
<td>0.73</td>
<td>2.06</td>
<td>5.46</td>
<td>4.90</td>
<td>71.10</td>
</tr>
<tr>
<td>May</td>
<td>1.60</td>
<td>4.23</td>
<td>0.85</td>
<td>18.96</td>
<td>53</td>
</tr>
<tr>
<td>June</td>
<td>0.77</td>
<td>3.87</td>
<td>0</td>
<td>2.32</td>
<td>17.40</td>
</tr>
<tr>
<td>July</td>
<td>0.70</td>
<td>0</td>
<td>0.37</td>
<td>3.47</td>
<td>18.20</td>
</tr>
<tr>
<td>August</td>
<td>1.40</td>
<td>0.30</td>
<td>0</td>
<td>19.36</td>
<td>46</td>
</tr>
<tr>
<td>September</td>
<td>0.44</td>
<td>0.81</td>
<td>38.60</td>
<td>59.60</td>
<td>38.40</td>
</tr>
<tr>
<td>October</td>
<td>0.24</td>
<td>5.70</td>
<td>46.12</td>
<td>64.90</td>
<td>38.35</td>
</tr>
</tbody>
</table>

Experimental results: Though data are available for two polarisations, only the results corresponding to horizontal polarisation are presented in this Letter. As expected, no polarisation effect has been detected regarding cloud attenuation, and the results for vertical polarisation are almost identical.

The time series of attenuation gathered throughout the experiment are classified according to the presence of various propagation impairments (clear sky, clouds, rain, etc.). The probability density function of experimental cloud attenuation, shown in Fig. 1, includes the attenuation component due to tropospheric gases, which cannot be separated accurately but has a much smaller variability. A very good agreement with a log-normal probability law (truncated), with a mean value of 2.23 dB and a variance of 0.29 dB, has been found after carrying out a curve fitting process. This result confirms the assumption made by the DAH model on the statistical distribution of cloud attenuation.

The cumulative distributions shown in Fig. 2 show the monthly variability of cloud attenuation for all 12 months of the year. In spite of the highest measured attenuation being 8.4 dB for 0.01% of the time in October, November presents the highest attenuation for most percentages. This can be attributed to a high percentage of occurrence (8%) of nimbostratus clouds (see Table 1). A high frequency of occurrence of certain types of clouds, such as cumulus, cumulonimbus and nimbostratus, has been detected in months that show higher attenuation, such as April, May, July, September, October and November.

Comparison with models: The experimental yearly cumulative distribution is compared to attenuation predictions obtained from several models. The Altshuler and Marr [2] and Dintemann and Ortgies [3] models use ground level meteorological data, such as temperature and relative humidity. The DAH model employs cloud statistics derived from SYNOP reports. The Salonen and Uppala model [5] and ITU-R Recommendation 840 [6] estimate the attenuation from cloud liquid water contents. Local radio-sounding profiles are used as input data to obtain the liquid water content in the Salonen and Uppala model, while Recommendation 840 includes maps detailing the global

References

Fig. 1 Experimental pdf of cloud attenuation and log-normal curve fitting

Fig. 2 Monthly cumulative distributions of experimental measurements