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# التوثيق الالكتروني والميكروفيلم

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## التوثيق الإلكتروني والميكروفيلم

## قسم

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MENOUFIA UNIVERSITY
Faculty of Electronic Engineering
Department of Electrical Communications
Menouf



# VOICE AND DATA INTEGRATION OVER MICROCELLULAR MOBILE RADIO NETWORKS



by

**Saied M. Abd El-atty**

(B.Sc.)

A Master Thesis Submitted in Partial Fulfillment of the Requirements for the M.Sc. Degree in Communications Engineering, Faculty of Electronic Engineering, Menoufia University.

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# MENOUFIA UNIVERSITY

## Abstract

FACULTY OF ELECTRONIC ENGINEERING

DEPARTMENT OF ELECTRICAL COMMUNICATIONS ENGINEERING

A Master Thesis of

# VOICE AND DATA INTEGRATION OVER MICROCELLULAR MOBILE RADIO NETWORKS

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A new concept is proposed for a dynamic length microcellular structure that has the potential to provide a communication link to all mobile users roaming in the service area. The implications of the system as well as its practical implementation are also addressed. Then, a queuing priority channel access protocol is presented for an integrated voice and data traffic on the air interface of a microcellular mobile radio network. As voice calls are time-critical and the interruption of a conversation is unbearable, the strategy aims at minimising this phenomenon. Data traffic, on the other hand, are served on a delay basis as the prompt delivery of data is not stringent. A methodology is developed for an accurate traffic modelling of the network when adopting the strategy. The traffic model is based on more realistic and sound concepts such as the evidently finite number of users roaming in a microcell as well as the impact of vehicular traffic flow on the traffic load. In addition, the effect of the hostile mobile radio channel on data transmission is considered. Handover traffic of both voice and data sources, handover priority, data queuing and the number of roaming mobile stations are accommodated in the model. The highway microcellular mobile radio network is considered as a case study. However, the analysis is fairly general to other microcellular scenarios. Performance metrics such as blocking, handover failure and service transfer to next microcell probabilities are derived from the state probability of the microcell base station. Numerical results are presented and discussed.

# NOTE ON PUBLICATION

A paper extracted from the research work of the MSc thesis

**Paper title:** A Queuing Priority Channel Access Protocol for Voice/Data Integration on the Air Interface of Microcellular Mobile Radio Networks

**Authors:** Mostafa Nofal, Nawal. El-fishawy and Saied Abd El-etty

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# LIST OF PRINCIPLE SYMBOLS

| | |
|---|---|
| $k$ | : cluster size |
| $CIR$ | : carrier to interference ratio |
| $\gamma$ | : propagation path loss exponent |
| $N$ | : number of channels per microcell |
| $B_T$ | : total frequency allocated of the network |
| $B_c$ | : channel bandwidth |
| $D_v$ | : traffic density on the road |
| $D_{jam}$ | : traffic density under jam traffic |
| $Q_v$ | : traffic flow on the road |
| $V_s$ | : space mean speed of vehicles |
| $V_f$ | : space mean speed for free flowing |
| $l_v$ | : headway distance |
| $\zeta$ | : the service penetration rate (average number of active mobile stations) |
| $L$ | : microcell length |
| $n$ | : number of lanes per direction |
| $M_u$ | : average number of roaming mobile stations in a microcell |
| $T_{MV}$ | : total duration of voice call |
| $T_{Md}$ | : total duration of data request |
| $\overline{T}_{Mv} = 1/\mu_{Mv}$ | : mean value of $T_{MV}$ |
| $\overline{T}_{Md} = 1/\mu_{Md}$ | : mean value of $T_{Md}$ |
| $T_i$ | : average residing time of a new user in the source microcell |
| $T_h$ | : average residing time of a handover user since the last handover till the next microcell |
| $\overline{T}_i = 1/\mu_i$ | : mean value of $T_i$ |
| $\overline{T}_h = 1/\mu_h$ | : mean value of $T_h$ |
| $F_{T_{Mv}}(t)$ | : the cumulative distribution function CDF of $T_{Mv}$ |
| $F_{T_i}(t)$ | : the cumulative distribution function CDF of $T_i$ |
| $T_{Hi}v$ | : the channel holding time of a new voice request |
| $F_{T_{Hi}}{}^{v}(t)$ | : the cumulative distribution function (CDF) of $T_{Hi}v$ |
| $T_{Hi}{}^{d}$ | : the channel holding time of a new data request |
| $F_{T_{Hi}}{}^{d}(t)$ | : the cumulative distribution function (CDF) of $T_{Hi}{}^{d}$ |
| $T_{Hh}v$ | : the channel holding time of a successfully voice handover request |

| | |
|---|---|
| $F_{T_{Hh}}{}^{v}(t)$ | : the cumulative distribution function (CDF) of $T_{Hh}v$ |
| $T_{Hh}{}^{d}$ | : the channel holding time of a data handover request |
| $F_{T_{Hh}}{}^{d}(t)$ | : the cumulative distribution function (CDF) of $T_{Hh}{}^{d}$ |
| $P_{iv}$ | : probability that successfully established a voice attempt |
| $P_{id}$ | : probability that successfully established a data attempt |
| $P_{hv}$ | : probability that successfully voice handover may need further handover before completion. |
| $P_{hd}$ | : probability that successfully data handover may need further handover before completion |
| $\alpha$ | : the fraction of the $M_u$ mobile users that generate voice calls |
| $\beta= (1-\alpha)$ | : fraction of data mobile users. |
| $\lambda_{iuv}$ | : the initiated voice call attempt rate per free user |
| $\lambda_{iod}$ | : the initiated data attempt rate per free user |
| $\lambda_{iud}$ | : the retransmitted initiated data attempt rate per free user |
| $\lambda_{huv}$ | : the voice handover rate per free user |
| $\lambda_{hod}$ | : the data handover rate per free user |
| $\lambda_{hud}$ | : the retransmitted handover data attempt rate per free user |
| $P_e = 1 - P_{succ}$ | : probability of the data error transmission |
| $f_D$ | : Doppler frequency shift |
| $\varphi$ | : wavelength of the radio frequency carrier |
| $S_{th}$ | : the receiver sensitivity threshold |
| $T_p$ | : the packet transmission time |
| $S_r$ | : the *rms* received signal level |
| $\overline{T}_H = 1/\mu_H$ | : the average channel holding time |
| $\mu_{qv}$ | : the departure rate by which a handover voice attempt will leave the queue |
| $\mu_{ed}$ | : the composite early departure rate |
| $P_B$ | : the blocking probability of new voice attempts |
| $P_q$ | : the queuing probability |
| $L_q$ | : the average queue length |
| $P_{fh}$ | : the failure probability of a handover voice attempt |
| $P_{ti}$ | : the transfer probability of a new data attempt |
| $P_{th}$ | : the transfer probability of a handover data attempt |