A Survey on Delay of Voice End User in Micro Macro Cellular System


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ABSTRACT

The Delay of Voice End (DOVE) user is a promising technique in enhancing the carrying of voice traffic on network. There are several analytical initiatives available for DOVE in voice data as an integrated service. In this paper, the same concept is applied to a micro-macro cellular system, where DOVE is applied at the end of user’s micro and macro cell separately in comparison to different traffic parameters. The impact of DOVE on call blocking probability in micro and macro cell has been analyzed to get feedback of offered traffic of both micro and macro cell that varies the delayed parameters.

Keywords: Carried Traffic; Overflow Traffic; GoS (Grade of Service), ERT and Markov Chain.

1. INTRODUCTION

One of the established call access strategies in mobile cellular network is to use guard channels to ensure a certain grade of service is widely accepted and implemented. This technique consists of having a fixed number of channels in each cell, which is exclusively reserved for overflow traffic of a particular type of service. These extra channels reduce the negative effect caused by dropping a call in progress providing the overall grade of service of the network. However, the drawback for using reserved channels for handoff calls is that the channels that are reserved may be unoccupied for a long duration and the service provider may lose huge revenue. Another strategy employed is queuing to improve the grade of service. Some schemes propose the interaction of a queue to deal with new originating calls, given the less restrictive delay constraint of this type of calls in comparison with handoff calls. Some articles like [1-5] propose queuing the handoff requests and variable reservation scheme considering prioritization of handoff calls over new originating calls. In this paper, in stead of incorporation of queue (buffer) that is a completely different but very simple scheme for improving the performance of the wireless networks by adopting some delays to the last user of the network. Here the end of voice user is kept awaiting called ‘Delay of Voice End-user’ (DOVE) found explicitly in [6]-[7]. To the best of our knowledge, there is no work in the literature, on the DOVE on micro-macro cellular system. In this paper, a new call arrives that will firstly search for free channel in the corresponding micro cell. In case of unavailability of channels, the micro cell will serve the macro cell. Any call under macro cell that continuously monitors for free channel of the micro cell of that location. In case of availability of channel at that micro cell, the call will be handover to the macro cell called signal take-back. The macro cell is only to support the overflow traffic of the micro cell. Here DOVE is applied at the both end-users of micro cell that is macro cell comparison.

The organizing of the papers is like: section 2, which deals with the concept of micro-macro cellular system and implementation of DOVE for both micro and macro cells based on Markov Chain. Section 3 depicts the analytical results of the project; finally section 4 concludes entire analysis.

2. MARKOV CHAIN IN MACRO-MICRO CELLULAR SYSTEM

Although the overflow traffic of a network is solved by Equivalent Random Theory (ERT) model [10]-[11] but in the paper Erlang’s distribution will be considered based on Markov Chain. Any probability state in micro-macro cellular system is indicated as $P_{xy}$ where $x$ is the number of channels occupied by micro cell and $y$ is the number of channels occupied by a macro cell. The state transition diagram is shown in fig. 2. The symbols used in the chain are:
Fig. 1: Micro-macro cellular system

- \( n \rightarrow \text{Total number of channels of a micro cell.} \)
- \( m \rightarrow \text{Total number of channels of a macro cell.} \)
- \( \lambda_1 \rightarrow \text{Call arrival rate in a micro cell} \)
- \( \lambda_2 \rightarrow \text{Call arrival rate in a macro cell} \)
- \( \mu_1 \rightarrow \text{Termination rate in a micro cell} \)
- \( \mu_2 \rightarrow \text{Termination rate in a macro cell} \)

Fig. 2: Markov chain of micro-macro cellular system

Solving the state transition diagram of fig.2 based on the concept of [12]-[17], the probability of complete occupied state of micro cell:

\[
P_{n0} = \frac{A_n^m}{n!} P_{00} \quad (1)
\]

Call blocking probability in macro cell:

\[
P_{\text{cm}} = \frac{\lambda_2^m}{\prod_{i=1}^{n}(n\mu_1 + i\mu_2)} P_{n0} \quad (2)
\]

\[P_{n0} = \frac{1}{\sum_{\lambda=0}^{n} \sum_{\mu=0}^{n} \lambda_1^n \mu_2^m \prod_{i=1}^{n}(n\mu_1 + i\mu_2)} \]

Fig. 3: DOVE at micro cell

2.1 Delay of Voice End-user at micro cell

Here the last user of micro cell will be delayed and a new probability state \((n-1, 0, D)\) is incorporated between \((n/\delta)\). The corresponding state transition chain is

Solving the chain, probability of complete occupied state of micro cell:

\[
P_{00} = P_{00} \frac{A_n^{n-2}}{(n-2)!} \beta_1, \quad (3)
\]

Probability of delay,

\[
P_D = P_{00} \left[ \frac{n\mu_1 + \lambda_1 - \frac{\lambda_2}{(n\mu_1 + \mu_2)}}{\delta} \right] \quad (4)
\]

Call blocking probability in macro cell,

\[
P_{\text{cm}} = \frac{\lambda_2^m}{\prod_{i=1}^{n}(n\mu_1 + i\mu_2)} \quad (5)
\]

\[P_{n0} = \frac{1}{\sum_{\lambda=0}^{n} \sum_{\mu=0}^{n} \lambda_1^n \mu_2^m \prod_{i=1}^{n}(n\mu_1 + i\mu_2)} \]

\[\beta_1 = \frac{\delta + (n-1)\mu_1}{\lambda_1} \{\lambda_1 + (n-1)\mu_1\}, \]

\[\beta_2 = \left[ \frac{1}{\delta} \left( n\mu_1 + \lambda_1 - \frac{\lambda_2}{(n\mu_1 + \mu_2)} \right) \right] \{\beta_1 - (n-1)\mu_1\} - n\mu_1 \]
2.1 DELAY OF VOICE END-USER AT MACRO CELL

The same delay of previous section is applied at the node \((n, m-1)\) before the last node \((n, m)\), shown in fig.4. We will find the probability of complete occupied state of microcell or \(P_{n0}\) and call blocking probability \(P_{mn}\).

Solving the chain,

\[
P_{n0} = \frac{A^n}{n!} P_{00}
\]

and

\[
P_{mn} = \frac{A^n}{n!} \sum_{i=1}^{\infty} \frac{\lambda_i^{n-1}}{(n+1)i} \left\{ \prod_{j=1}^{n-1} \left(\frac{n\mu_i + j\mu_i}{(n+1)i}\right) + Q + Z + T \right\}
\]

Where

\[
P_{00} = \sum_{i=1}^{\infty} \frac{A^n}{n!} \sum_{j=1}^{\infty} \frac{\lambda_j^i}{(n+1)i} + Q + Z + T
\]

\[
L = n\mu_i + (m-1)\mu_2 + \lambda_2,
\]

\[
R = n\mu_1 + m\mu_2,
\]

\[
Q = \frac{A^n}{n!} \sum_{i=1}^{\infty} \frac{\lambda_i^{n-1}}{(n+1)i} \left\{ \prod_{j=1}^{n-1} \left(\frac{n\mu_i + j\mu_i}{(n+1)i}\right) + Q + Z + T \right\}
\]

\[
Z = Q \frac{R}{\lambda_2} \quad \text{and} \quad T = Z \frac{R}{\lambda_2}
\]

3. RESULTS AND DISCUSSIONS

Fig.5 and 6 depict the results for the case of delay at the end of macro cell users. Fig.5 (a) shows the variation of blocking probability of micro cell against offered traffic of micro cell taking \(\delta\) as a parameter. Here delay is applied at the end of macro cell user so \(\delta\) has no impact on blocking of micro cell visualized form fig.5 (a). Fig. 5(b) shows the variation of the same parameters for macro cell. Here blocking probability increases with increased in both \(\delta\) and offered traffic of micro cell. Fig.6 shows the similar result against the offered traffic of macro cell. In fig.6 (a) the blocking probability in micro cell seems invariant with respect to offered traffic on macro cell. But that of macro cell varies against the same parameter visualized from fig.6 (b).

![Fig. 5: Delay at the end of macro cell user](image-url)
(a) Blocking Probability of (a) micro cell against offered traffic of macro cell, and (b) macro cell against offered traffic of macro cell.

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**Fig.6:** Delay at the end of macrocell user

The delay at the end of macrocell user is visualized. The blocking probability is shown against the offered traffic of microcell and macrocell for different values of δ. The graphs are composed of three subfigures, each representing a different value of δ. The x-axis represents the offered traffic of macrocell (Erls), and the y-axis represents the blocking probability.

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**Fig.7:** Delay at the end of microcell user

The delay at the end of microcell user is also visualized. The blocking probability is shown against the offered traffic of microcell and macrocell for different values of δ. The graphs are composed of three subfigures, each representing a different value of δ. The x-axis represents the offered traffic of microcell (Erls), and the y-axis represents the blocking probability.

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**Fig.8:** Delay at the end of microcell user

The delay at the end of microcell user for the second scenario is visualized. The blocking probability is shown against the offered traffic of macrocell for different values of δ. The graphs are composed of three subfigures, each representing a different value of δ. The x-axis represents the offered traffic of macrocell (Erls), and the y-axis represents the blocking probability.
Fig. 9 shows the variation of blocking probability against $\delta=1/\text{delay}$ for both macro and micro cell for the case of delay at the end of macro cell user. The impact of $\delta$ is visualized for macro cell but there is no impact of $\delta$ on blocking probability of micro cell.

![Fig. 9: Delay at the end of macro cell user](http://www.scientific-journals.org)

Fig. 10 shows the variation of blocking probability against $\delta=1/\text{Delay}$ for both macro and micro cell for the case of delay at the end of micro cell user. The blocking probability of both micro and macro cell increases with increase in $\delta$.

![Fig. 10: Delay at the end of micro cell user](http://www.scientific-journals.org)

Figures 11 and 12 show the blocking probability micro and macro cell against offered traffic of macro cell for both case of delay of end-user. Here offered traffic has no impact on blocking of micro cell. Same is occurred in fig. 13 and 14 varying offered traffic of micro cell, where the ultimate blocking probability is found much less in case of delay at micro cell.
4. CONCLUSION

The results of the paper reveals that the overall performance of the network is enhanced with incorporation of DOVE at both micro and macro cell. For a network under overloaded condition, DOVE at macro cell is preferable, which is compared to that of micro cell. The entire analysis of the paper is done based on one dimensional Markov Chain method, where call arrival rate consists of new originating calls and hand off calls. If two arrival rates were segregated and two dimensional Markov Chain were applied then we can expect more accurate results.

REFERENCES


