Traffic Models for 4G applications by considering intra-system interference

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Abstract

In the same frequency networking environment, the neighbor cell density is evenly user (neighboring cell are equal when the number of users), the total throughput of the single-user and the variation of the cell as follows:Network traffic prediction, data flow prediction model plays an important role. There are some differences in the data business model than traditional circuit domain model, the circuit domain model analysis usually discrete state Markov model, the existing network of environmental data and business user reach you obey Poisson distribution, long exponentially distributed service, and each user exclusive a channel resources. To improve data flow model consistency with the existing network, improve network planning rationality, based on the business itself and the community in line with the rate of change in the characteristics of a continuous process (and users to share data resources), and traffic flow model with the more common: such as roads and resources channel resources are shared resources, user rates are in line with the continuity of the trend. When a small number of users, the total throughput of the cell to maintain stability in the higher range, and the rapid decline in single-user rate trends; while large number of users, the total throughput of the cell to some extent, remain stable, and the single-user rate decreased gradually slowdown.

Introduction

Existing Communication Model apply to the circuit domain model, a communication system such as GSM and TD-SCDMA voice systems. Because each user exclusive resource, such as frequency, time slot or code channel. Therefore, it is reasonable to adopt the Erlang Service Model. Subsequent data services using the equivalent :

$$\text{number of users supported} = \frac{\text{The amount of data to be transmitted}}{\text{The average rate}} \ (1 + \text{Allowable bit error rate})$$

In this way determine the nature or exclusive resources and allows the user error rate, the calculation of the number of users. This model is not applicable to a scheduling mechanism for sharing the communication resource system, modern mobile communication scheduling mechanism usually proportional fairness, the user needs to consider the size of data to be transmitted, a certain historical information and current SNR, the pattern itself of such is no longer a Markov process [1]. The state transition diagram can be expressed as:

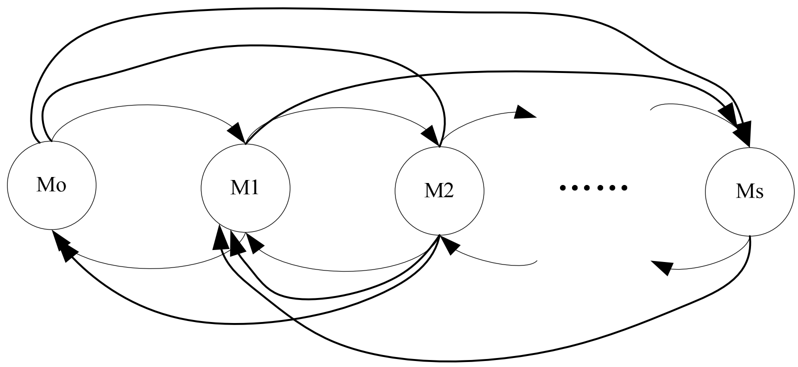

Fig. 1Continuous state of non-state Markov process transition diagram

In the above formula, Mo .. Ms indicates the minimum and maximum cell throughput, Mi represents the cell throughput may be, is a continuous real number between Mo ~ Ms, there are numerous possible throughput of the cell, and each state may jump directly to another state variable, therefore, resource sharing communication system with scheduling mechanism is not birth-death process in the traditional sense, therefore, the business model does not apply to the circuit domain of modern data services models.

Method solution

The program provides a new data Communication Model. Are two important features of modern mobile communication system is a scheduling and resource sharing mechanisms. Thus, certain factors affecting the cell is very large, such as the scheduling mechanism, the user service, the radio network resource configuration or structure of the cell will affect the throughput. Therefore, can't be given directly mapped directly between these factors and cell throughput. This patent discloses the use of statistical data to establish a business model approach, the model is based on the following two assumptions:

1) When a smaller number of users, due to lower network interference, with the increase in the number of users, the cell throughput will be improved, while the single-user throughput was significantly decreased; linear model can be used.

2) The number of users reaches a certain threshold, the result of higher network interference; With the increase in the number of users, the cell throughput will decrease, while the single-user throughput will be decreased slowly; can be exponential model.

Cell throughput can be expressed as :

$$q = k * u(k) \tag{1}$$

In which, k is the number of users a cell to be transmitted; u (k) is the k-th user to be transmitted, based on the average transmission rate of the user. In the linear model conditions:

$$u(k) = u_{f,1} * \left(1 - \alpha \frac{k}{k_{m1}}\right), \quad (1 \le k < k_{m1}) \tag{2}$$

$u_{f,1}$ is a single-user user rate conditions; critical point k_m1 linear model and the exponential model between the number of users. α is the model correction factor.

Under the exponential model conditions:

$$u(k) = u_{f,m1} * e^{-\beta \frac{k}{k_{m2}}}, \quad (k_{m1} \le k \le k_{m2}) \tag{3}$$

$u_{f,m1}$ is the number of users in k_{m1}, the average rate of users; k_{m2} exponential model is consistent with the maximum number of users; β is a model correction factor.

Based on the above reasoning, the establishment of sub-models, building the relationship between the cell throughput and the number of users. Formula is as follows:

$$q = \begin{cases} k * u_{f,1} * \left(1 - \alpha \frac{k}{k_{m1}}\right) (1 \le k < k_{m1}) & \text{(Linear model)} \\ k * u_{f,m1} * e^{-\beta \frac{k}{k_{m2}}} \quad (k_{m1} \le k \le k_{m2}) & \text{(Exponential model)} \end{cases} \tag{4}$$

α and β are the model correction coefficient, the correction coefficient requires two fitting or simulation based on the test sample. α and β is the business model, a comprehensive reflection of scheduling mechanism, network interference and other conditions.

Based on the above sub-model, the relationship are given the best possible number of users and the best throughput. After differentiating k model calculates the optimal number of users, and into the equation, we get the best throughput. The results were as follows:

In the linear model: the optimal number of users $k = \frac{k_{m1}}{2\alpha}$; Optimal Throughput $q = \frac{K_{m1} u_{f,1},}{4\alpha}$.

In the exponential model: the optimal number of users $k = \frac{K_{m2}}{\beta}$; Optimal Throughput $q = \frac{K_{m2} * u_{f,m1} * e^{-1},}{\beta}$

According to TD-LTE field testing environment[2]., the authentication method of the present patent. Reference LTE field test data, Uf largest single user access rate = 60.4mbps, Km of 200 people:

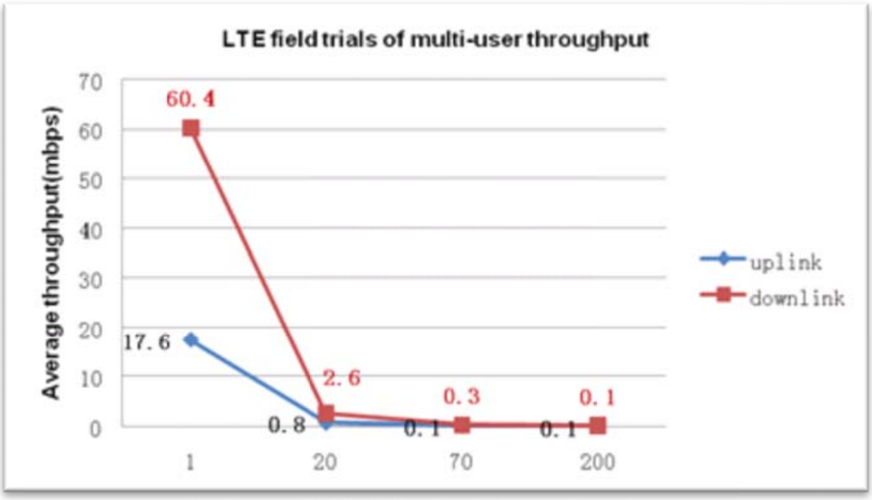

Fig. 2 LTE field trials of multi-user throughput

Fig. 2 shows: the single-cell users, downstream throughput are as follows: With the rapid decline in the number of users increases, the density of up to 20 people and the user, the user density impact on the average throughput decline gradually slowing down.

In order to establish a more detailed user rate, density relations, more effective model predictive trend analysis, performed excerpts from the cell downlink throughput characteristics estimated by piecewise functions, as follows:

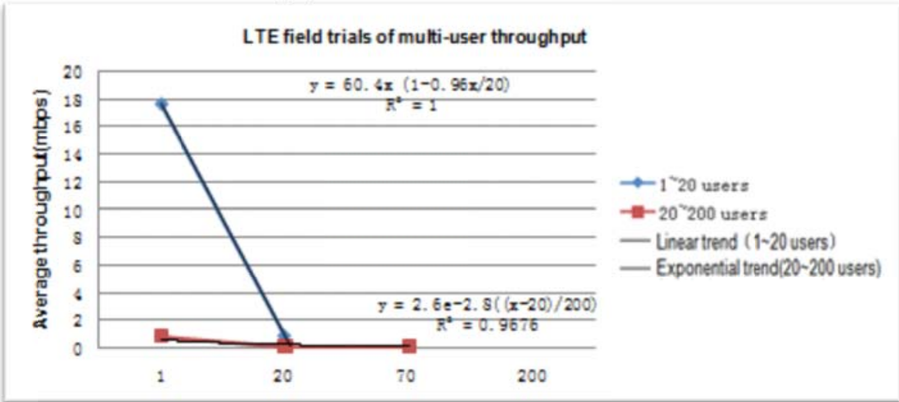

Fig. 3 LTE field trials of multi-user throughput

Select required to be fitted on each function according to current network statistics and piecewise functions, select a higher degree fitting function. Models conform to the linear model, exponential model and segmentation model, due to the higher segment models and field test data fitting degree, its conclusions are as follows:

Fig.3 shows: when the cell is less than or equal to 20 the number of users who reference type 1.1 users with an average throughput density decreased more rapidly with a higher degree of fitting a linear trend; When the number of users in a cell of 20 to 200 people, a reference formula 1.2 users with an average throughput density decreased gradually slowing trend goodness of fit index higher.(R^2Trends and field as a model goodness of fit test data R^2 Close to 1 represents a higher degree of curve fitting, goodness of fit is low and vice versa.)

Communication model density correction value α, β is derived as follows:

When the user density k, subsection function with $1 \leq k \leq 20$

$$u = u_{f,m1} * (1 - \alpha \frac{k}{k_{m1}}) \tag{5}$$

$$\alpha = \frac{u_{f,m1} - u}{u_f} = 0.96 \tag{6}$$

When the user density k, subsection function with $20 \leq k \leq 200$

$$u = u_{f,m2} * e^{-\beta \frac{k}{k_{m2}}} \tag{7}$$

$$\beta = ln\left(\frac{k}{k_{m2}}\right) = -3.11 \tag{8}$$

While the cell less than or equal to 20 users reference model density correction value: $\alpha = 0.96$

While the users in a cell of 20 to 200 users reference model density correction value :$\beta = -3.11$

Single-user request rate (single-user throughput) can not reflect the maximum throughput of the cell, and determine the existence of two cell throughput variation, so the best user density residential complex values.

If k representative can achieve optimal cell density of users, then:

When the user density k, subsection function with$1 \leq k \leq 20$,

$$u = u_f * (1 - \alpha \frac{k}{k_m})$$

$$k = \frac{k_m}{2\alpha} \approx 10$$

$$q = k * u_{f,m1} * \left(1 - \alpha \frac{k}{k_{m1}}\right) = 61.7$$

While the cell less than or equal to 20 users, the average user throughput speed decreases linearly with density and residential users reached 10 district best user density, the maximum throughput of 61.7Mbps.

When the user density k, subsection function with $20 \leq \mathrm{k} \leq 200$,

$$\mathrm{u} = \mathrm{u_f} * \mathrm{e}^{-\beta\frac{\mathrm{k}}{\mathrm{k_m}}}$$

$$\mathrm{k} = \frac{\mathrm{k_m}}{\beta} \approx 64$$

$$\mathrm{q} = \mathrm{k} * \mathrm{u_{f,m2}} * \mathrm{e}^{-\beta\frac{\mathrm{k}}{\mathrm{k_{m2}}}} = 31.4$$

While the users in a cell of 20 to 200 users with the average user throughput density decreased gradually slowed down, and the district reached 64 people when the user community the best user density, the maximum throughput of 31.4Mbps.

Conclusion

In the same frequency networking environment, the neighbor cell density is evenly user (neighboring cell are equal when the number of users), the total throughput of the single-user and the variation of the cell as follows: While neighbor cell interference is small, compared to single-user peak rate high on average more system resources (resource allocation principles found), the number of users with a certain single user changes linearly, the total throughput remains close to the cell; when neighboring cell interference is large, the lower single-user peak rate, single-user throughput volume index decreased with the number of users, and the total throughput of the cell remained stable in the lower range.

References

1.R. E. Bellman. Dynamic Programming. Princeton University Press, Princeton, NJ, 1957. Dover paperback edition (2003), ISBN 0-486-42809-5.

2. China Mobile Group TD-LTE 2011 network field testing result of‘Performance And Network Quality’.