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Multiple Linear Regression Application on the Inter-Network Settlement of Internet

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Abstract: *This paper develops an analytical framework to explain the Internet interconnection settlement issues. The paper shows that multiple linear regression can be used in assessing the network value of Internet Backbone Providers* (IBPs). *By using the exchange rate of each network, we can define a rate of network value, which reflects the contribution of each network to interconnection and the interconnected network resource usage by each of the network.*

Key words: *multiple linear regression; network value; internet; settlement*
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1 Introduction

The question discussed in this paper is how to settle among IBP. The internet industry is dynamic. The number of Internet Service Providers (ISP) is increasing rapidly and the structure of the industry change continuously[1].

Telecommunications industry has always focused the attention on the disputes of internet interconnection; especially interconnection settlement between networks has become one of the problems urgently to be solved[2]. Recently, with the frequent emergence of the problems on interconnection, inter-network settlement has become the focus in our country telecommunications industry.

There are two ways of interconnection: Network Access Points(NAP) and peering[3]. There are three ways of inter-network settlement: non-settlement, multi-parties settlement, bilateral settlement. When two parties of interconnection receive the equal benefits from internet interconnection, non-settlement is usually implemented, which often emerges among the same level network operators. Multi-parties settlement is often implemented in public switching centers applying multi-parties peering protocol; this kind of settlement can implement different pay-off structures. Bilateral settlement is enforced by both parties of interconnection negotiation[4]. At NAPs, China Telecom and China Netcom exchange the traffic through bill-and-keep, but when other networks exchange the traffic with these two networks , they pay the certain charges to both of them (single-direction settlement is employed) while network rates is decreased by half. This method of settlement has been taken questions by many parties, especially some smaller profit-oriented IBP connecting to NAP.

This paper develops an analytical framework to explain the internet interconnection settlement issues. The paper uses multiple linear regression to estimate the network value of each IBP, and then brings forward the settlement method of network value weighed exchange rate margin, while take comparison to the settlement method implemented by MII on May 1st 2004. The paper reaches some conclusions in the following fashion. The next section describes the theoretical foundation of constructing settlement method. Section 3 introduces the specific process of constructing settlement method. Section 4 uses data to simulate the settlement model; finally we get some conclusions about settlement.

2 Theoretical Foundatioin

Some principles on international charging arrangements for internet services are put forward in 2000 APEC ministerial meeting on telecommunications and information industry[5]. International charging arrangements for internet services between providers of network services should be commercially negotiated and, among other issues, reflect: 1) The contribution of each network to the communication; 2) The use by each party of the interconnected network resources; 3) The end to end costs of international transport link capacity[6]. We use network value to represent the contribution of each network to communication; the use by each party of the

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interconnected network resources, which is other network users' visit to their own network resources can be measured by the traffic, however, given the higher cost of measuring traffic, we use data exchange rate to displace it, practically this part is the variable cost in the interconnection, but because it is not a linear function of traffic, we choose the actual method of collecting data at NAP; the third part is the fixed cost arose in interconnection. At the NAP, we require the backbone network linking to NAP to take on the fixed cost of interconnection link of this segment of distance from its network to NAP.

In the settlement, we only consider the first two parts.

3 Method

This section assesses the problems associated with measuring the value of the network for the purposes of billing under a settlement arrangement.

v_{ij}: In Fig. 1: The data exchange rate from IBP_i to IBP_j at the NAP. We collect the data exchange rate from IBP_i to IBP_j at 5-minute intervals, then we can obtain a group of data transfer samples, as the group described above in the each settlement cycle, we get rid of the maximal value of 5% and the arithmetic average value of residual maximal value is the data exchange rate from IBP_i to IBP_j at the NAP. We call this the 95th percentile calculation.

r_i: The network value of IBP_i

r_j: The network value of IBP_j

f_{ij}: The network value weighed data exchange rate margin, $f_{ij} = \frac{r_i}{(r_i + f_j)/2} v_{ij} - \frac{r_j}{(r_i + r_j)/2} v_{ji}$

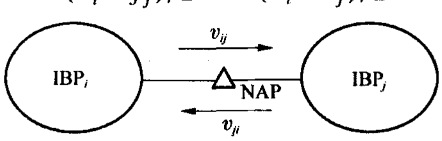

Fig. 1 Two internet backbones interconnection at the NAP

Supposed there are n IBP linking to NAP, the factors of influencing the network value of the IBP are: network coverage scope, the number of users, network bandwidth and the number of Point-of-Presence, access point of network(POP) and so on.

The network value reflects its profit ability finally, so we can use overall revenue R of all IBP to displace the network value of all IBP.

According to the factors influencing network value, we assume linear relation below:

$$R = (\alpha, \beta, \lambda, \delta, \xi, \eta)(\text{city}, u, k_1, k_2, \text{POP}, \text{ISP})^T \quad (1)$$

where city is coverage scope of all IBP, u is ordinary users, k_1 is international bandwidth, k_2 is domestic bandwidth, POP is the number of POP, ISP is the number of ISP.

We collect m time serial data of n IBP linking to NAP based at one-month intervals. We can know:

$$(\text{city}, u, k_1, k_2, \text{POP}, \text{ISP}) = \sum_{i=1}^{n} (\text{city}, u, k_1, k_2, \text{POP}, \text{ISP})_i \quad (2)$$

According to Eqs. (1) ~ (2), we take computation analysis to m serial data, and find common parameter: $(\alpha, \beta, \lambda, \delta, \xi, \eta)$, so we can get network value of each IBP:

$$r_i = (\alpha, \beta, \lambda, \delta, \xi, \eta)(\text{city}, u, k_1, k_2, \text{POP}, \text{ISP})_i^T$$

Furthermore:

$$f_{ij} = \frac{r_i}{(r_i + r_j)/2} v_{ij} - \frac{r_j}{(r_i + r_j)/2} v_{ji} \quad (3)$$

That is network value weighed data exchange rate margin between backbone network i and backbone network j.

4 Simulation

4.1 Effect Factors

In the selection of factors, the availability of data is the major concern. If we can't obtain the data, the method of settlement is difficult to be applied practically. Another consideration is the linear relativity between data; essentially we use two repeated variables to denote one affecting factor, which is not necessary and put trouble to computation. So we choose the number of POP but not the number of cities to indicate the IBP's coverage scope.

Table 1 Factors of affecting network value

Factors	Indicators	Symbols
Network users	Ordinary users	u
Internet backbone capacity	International bandwidth	k
ISP	The number of ISP	ISP
Geographic coverage	The number of POP	POP

The computation of the number of ISP is based on the city coverage, which equals with the sum of the number of ISP hold by the cities of network coverage. There may be another instance that is in certain city, one ISP may link to different IBP. If it links to m IBP, we can view it as m ISP when counting the sum of ISP. While counting the number of the ISP of an IBP, we only view it as one ISP. Table 2 show the counting table of the number of the ISP, the number of the ISP of one backbone is just equal with the multiplier between the number of cities and the number of the ISP of certain IBP in this market.