Network Demand Model
and Global Internet Traffic Forecasting

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ABSTRACT

The need for a network demand model arises as the importance of access to the Internet to deliver essential services increases. The ability to anticipate bandwidth needs is critical for efficient service provisioning and intelligent decision making in the face of rapidly growing traffic and changing traffic patterns. The purpose of this paper is to develop a network demand model to explain the current and future flow of Internet traffic around the globe and thereby understand the future bandwidth needs for domestic as well as for the international links. We develop a model based on previously observed traffic patterns and the theory of network externality. Based on this network externality concept, we assume that the flow of traffic among different countries around the world is directly linked with the relative number of hosts available in those countries. The model is then used to predict future traffic flow among seven regions in the world, distinguishing between domestic and international traffic and inbound versus outbound traffic for each region.

1. INTRODUCTION

The need for a network demand model arises as the importance of access to the Internet increases for the delivery of essential services. It is even more important as the dramatic increase in the number of Internet users and their usage demands in recent years causes serious burdens to the local access and backbone networks [Kumar 1997]. The ability to anticipate bandwidth needs is critical for efficient service provisioning and intelligent decision making in the face of rapidly growing traffic and changing traffic patterns[1]. Some aggregate level predictions for global economy are available in the existing literature regarding the number of users, the number of hosts and the prediction for total internet traffic [Negroponte 1996, Basu 1996, Rutkowski 1997, Internet Society 1998, MIDS]. Detailed analyses are available regarding the growth of Internet traffic for isolated regions. For example, Coffman and Odlyzko [1998] studied the possible growth of Internet traffic in the U.S. However, no comprehensive forecasting model has been developed to predict the Internet traffic flow among different countries in the entire world. The purpose of this paper is to develop a network demand model to explain the current and future traffic flow around the globe and thereby to understand the future bandwidth needs for domestic as well as international links.

However, due to the discontinuation of NSF data collection since the 2nd quarter of 1995 and the lack of other sources of systematic time series data for global traffic flow, it is difficult to estimate any standard econometric demand model. Therefore, we develop a demand model for Internet traffic based on previously observed traffic patterns and the theory of network externality. It has been long recognized that externalities exist in the demand function of individual telephone users. With that observation, we assume that similar externalities exist in the demand function of individual Internet users. Based on this assumption, the model developed in this paper assumes that the flow of traffic among different countries is directly dependent on the relative number of hosts available in those

[1] Since the introduction of the World Wide Web (WWW) in 1993, there has been explosive growth in Internet traffic. Recent statistics show that the number of Internet users in the world has increased from 39 million in October 1995 [MIDS, 1996] to 150 million in 1998 [Internet Soceity, 1998]. With the popularity of the Internet and WWW technologies, bandwidth-demanding multimedia traffic is becoming the major portion of the Internet traffic.

countries.

It is interesting to note that Internet traffic forecasting is rather unique compared with other goods and services, especially the forecasting of international Internet traffic. Generally, the demand for most goods and services are positively co-related to the growth of the general economy. On the other hand, the demand for information goods like Internet traffic flow generated by any country primarily depends on the growth of the information infrastructure within that country which may not have a one-to-one relation to the growth of the general economy. The investment required for the development of this kind of infrastructure is very high. The economic and social benefits that can be derived from this kind of infrastructure is also high. Therefore, the growth of Internet infrastructure in any country is highly dependent on the government policy towards such development. Since the focus of our study is to predict the Internet traffic flow among different countries, knowledge of the level of the domestic infrastructure is not enough. Additional knowledge about the state of Internet connectivity among different countries is crucial for total traffic prediction. Variations in language and culture among different countries could also influence traffic flow. Countries with the same language and similar cultures are likely to generate more Internet traffic transaction among themselves than otherwise.

In the present model, the aspect of country specific growth of infrastructure is taken into consideration by using information about the number of hosts for different countries. The state of Internet connectivity among different countries in the world is also implicitly incorporated in our analysis by using the available NSF traffic history of inbound and outbound traffic of different countries. However, the role of language or cultural aspects is not considered in our present model.

The model developed in this paper could be useful in several ways. First, the prediction based on the model provides us with a macro-level picture of Internet traffic and helps us estimate the future bandwidth needs around the world. Second, because of the direct link between the flow of international and domestic traffic, it provides us a way to understand the future domestic bandwidth needs for completing international traffic efficiently. Third, the incorporation of the externality argument in the model allows us to explain the often observed asymmetric traffic flow between two countries.

The paper is organized into 5 sections. In Section 2, we describe the global traffic demand model based on previously observed traffic patterns and the theory of network externality. In Section 3, the empirical implementation of the model is discussed. Prediction of the model is presented in Section 4, followed by some concluding remarks in Section 5.

2. A NETWORK DEMAND MODEL

Internet network demand can be measured along two dimensions. The first dimension is the time period that users are actively connected to the Internet and the second is how much network capacity the users are using. Because the Internet system is based on a packet-switching system, the duration of time connected to the Internet greatly depends on the efficiency of the movement of packets between different IP addresses. On the other hand efficiency of the movement of the packets depends on the modem speed at the user's end and the supply and demand condition of the network capacity. The lower the speed of the modem and the higher the congestion in the network, the slower is the speed of packet movement. The present paper focuses on analyzing the demand for network capacity rather than the duration of time connected to the network. Since each packet in the Internet carries a certain number of bytes worth of information, network traffic could be defined in terms of bytes. As the traffic travels through the network, the network capacity is used. Therefore, one way to estimate the demand for network capacity is to estimate the demand for moving some number of bytes in a specific time period within and among different countries.

In formulating the network demand model for global Internet traffic, we need to identify the factors that determine the movement of traffic within and among different countries. The most important characteristics of the demand for information goods like Internet traffic is that the realization of the demand for such goods depends on the availability of the communications infrastructure and the cost of using it. The primary factors that determine the movement of global Internet traffic are as follows:

i) User's need of traffic transaction and his/her affordability to access and use the network service.
ii) Available communication infrastructure within the user's own country and the connectivity of it with rest of the countries in the world.
iii) Cost of moving the traffic through the network.

Although the network service cost is either free or negligible to individual users due to the current pricing structure, it is not in fact free to the institutions or to the companies who buy the network service from providers for their members. Therefore, price does not playing an important role in influencing the individual user's demand but it could affect the demand at the institution or company level. The user's need, on the other hand, directly or indirectly depends on the socio-economic condition and the technological environment of the country where the user lives. However, the publicly available data related to Internet traffic and the information about the Internet infrastructure around the world is very limited. Being subject to this data constraint, it is difficult to estimate any standard econometric demand model to explain the current and future flow of traffic within and among different countries. Therefore, a simple model is developed for explaining the growth of global Internet traffic subject to the publicly available data and relying on the theory of network externality.

From experience, we know that network based telephone services have long been recognized as a case in which important externalities exist in the demand functions of individual consumers [McNamara 1991; Wenders 1987; Katz 1986]. A simple interpretation of the network externality in the context of telephone usage is as follows: An increase in the network size offers subscribers and potential subscribers the option of reaching more telephones. This option can increase willingness-to-pay for access and also usage per telephone, thereby increasing the total usage of telephone services. This phenomenon could be defined as the network externality in the context of telephone service demand. This kind of network externality effect in demand behavior could appear due to either an increase in the penetration rate with no expansion of population or an increase in the number of telephones with no change in the penetration rate. The former case of network expansion takes place mostly in developing countries, whereas the later case of expansion is more common in developed countries where universal telephone service has existed for many years [Taylor, 1995]. Similar network externalities are likely to exist in the demand function of individual Internet users of different countries in the world. Based on this externality concept, we can assume that the flow of traffic among different countries is directly dependent on the relative number of hosts in those countries. If the number of sites or hosts of a country represents a very small share in the Internet world, then it is likely that this country will receive more traffic than it will send.

Once we have the information about the total world traffic and the number of hosts by country, the model developed in this section will allow us to estimate the total traffic for each country, the share of domestic versus international traffic and the inbound and outbound international traffic.

To develop a methodology for measuring the demand for traffic transactions, we make the following basic assumptions:

i) Network externality exists in the demand function of individual Internet users.

ii) Information available in all the sites are equally important to relevant Internet users.

iii) Users in any country have identical behavior.

iv) A positive correlation exists between the number of users and the number of hosts in any country.

v) A positive correlation exists between the number of sites and the number of hosts in any country.

To develop the model, let us define some variables.

Variable Definition

TW_t: Total world traffic generated by n countries together in period t.

T_{it}: Total Internet traffic (inbound + outbound) associated with country i $(i=1, \ldots, n)$ in period t.

H_{it}: Number of hosts in country i in period t.

f_{it}: Share of the i-th country for total traffic generated in period t.

d_{it}: Share of domestic traffics in total traffic of country i in period t.

$1-d_{it}$: Share of international traffics in total traffic of country i in period t.

D_{it}: Total domestic traffics of country i in period t.

I_{it}: Total international (inbound + outbound) traffic for country i in period t.

r_{ijt}: Proportion of the international (inbound + outbound) traffic between country i and j in period t.

I_{ijt}: Total international (inbound + outbound) traffic between country i *and* j.

a_{ijt}: Proportion of international traffic which flows from country i to j, i.e., outbound international traffic from country i to country j in period t.

I_{ijt}^{out}: Outbound international traffics from country i to country j in period t.

I_{ijt}^{in}: Inbound international traffics of country i from *country* j in period t.

Based on the model assumptions, the relationships among variables defined above can be represented as follows.

The total world traffic is the sum of the traffic associated with n countries. That is,

$$TW_t = \sum_{i=1}^{n} T_{it}.$$

Using the information about the number of hosts in each country, f_{it} , the share of traffic of country i in total world traffic for period t, and T_{it} , the total traffic of country i in period t can be represented as

$$f_{it} = \frac{H_{it}}{\sum_{j=1}^{n} H_{jt}} \quad and \quad T_{it} = f_{it} * TW_t.$$

The share of domestic traffic d_{it}, total domestic traffic D_{it}, and total international traffic I_{it} for country i in period t can be represented as

$$d_{it} = \frac{H_{it}}{\sum_{j=1}^{n} H_{jt}}, \quad D_{it} = d_{it} * T_{it}, \text{ and } I_{it} = T_{it} - D_{it}.$$

Once we know the total international traffic I_{it}, the proportion of international traffic between country i *and* j, r_{ijt} and the total international traffic between country i *and* j, I_{ijt} in period t are given by

$$r_{ijt} = \frac{H_{jt}}{\sum_{k=1}^{n} H_{kt}}, for\ i, j = 1, \ldots, n \ \ and\ i \neq k, i \neq j,\ I_{ijt} = r_{ijt} * I_{it}.$$

From this, we can see that $I_{it} = \sum_{j=1}^{n} I_{ijt}$ for i,j=1,2, … ,n and $i \neq j$.

Finally, $a_{ijt.}$ the proportion of outbound international traffic from country i to country j, *and* the outbound and inbound traffic between country i *and* j, I_{ijt}^{out} , I_{ijt}^{in} in period t are represented as

$$a_{ij} = \frac{H_i}{H_i + H_j}, \ i \neq j,\ I_{ijt}^{out} = a_{ij} * I_{ijt}, \text{ and } I_{ijt}^{in} = I_{ijt} - I_{ijt}^{out}.$$

Sometimes we can estimate the values of a_{ijt} from the historical time series data of actual inflow and outflow traffic between country i and j if that data are available. This additional information will allow us to improve the estimate of our model parameters and also allow us to reduce the prediction error. One point to emphasize is that the inbound traffic for one country is the outbound traffic for some other countries. Therefore, total international inbound traffic is always equal to total international outbound traffic. This is true in the domestic arena also. Therefore, any traffic distribution methodology must satisfy the above mentioned equality.

With the information about total traffic TW_t and the information about the number of hosts in different countries H_{it}, we can estimate the total traffic generated by each country T_{it} by using the above methodology. Then based on the information about the number of hosts in each country and applying the above methodology, we can estimate the domestic and international traffic for each country and can determine the inflow and outflow of traffic among different countries.

Ideally, the total traffic generated by each country can be estimated based on the information about the number of users in any country, the average number of hours spent by each user, and the average number of bytes sent and received by each user per hour in that country. The problem is that it is very difficult to obtain information about current and historical records of number of users and usage level by country. However, with the reliable information about total number of hosts, the host count by country from Network Wizard, and time series data (until the first quarter of 1995) for total traffic on NSFNET backbone [Merit Inc.], a model is developed to utilize the number of hosts, rather than number of users.

Forecasting of Internet Traffic

To predict the future traffic flow within and among different countries, we need a separate model to predict the number of hosts by country and the total traffic generated by all countries. Then, we can estimate the traffic flow among different countries using the above methodology. Since the time series data of number of hosts by country is rather limited, we can use an alternative method to predict the future traffic flow of each country. We first develop a time series forecasting model for predicting the total number of hosts and average traffic per host using historical data on those variables. Then we predict the total world Internet traffic by multiplying the forecasted value of total number of hosts by that of average traffic per host. Once we estimate the total traffic, we can distribute the traffic flow among different countries assuming that relative distribution of number of hosts among different countries will remain unchanged in near future. Only the level of number of hosts will change due to growth. This implies that hosts in all countries are growing at the same rate and the relative structure of usage behavior is unchanged (the first assumption is supported in the existing literature). Because our prediction of average traffic per host is based on NSFNET data, which does not reflect the explosive growth in Internet traffic during 1995 and 1996, we can argue that our prediction will provide an estimate of the lower bound of the future Internet traffic flow around the globe. Figure 1 illustrates the method of estimating the domestic and international traffic for each country as well as the inbound and outbound traffic among different countries for n=3 using the information about the number of hosts by country and the total world Internet traffic.

3. EMPIRICAL IMPLEMENTATION OF THE MODEL

To implement the model developed in Section 2, we include all the major countries in the world, which are currently using Internet technology. They are responsible for almost 90% of Internet traffic. Selected countries are segmented into 7 groups: US, Canada, Australia, Europe, Asia, South America, and Africa. Each group includes most of the countries, which are relevant for estimating the expected demand in the near future. We first develop the model using NSFNET traffic history (March 1991-December 1994) provided by Merit Inc. and the history of number of hosts (July 1981 to January 1998) produced by Network Wizards. The NSFNET traffic mainly represents traffic generated within the US or between the US and other countries. No systematic statistics regarding traffic for countries outside NSFNET were available. The following methodology is used to estimate the traffic flow among countries outside the NSFNET: we estimate the average traffic generated per host in the US and combine that information with the information about hosts for different countries to interpolate the traffic pattern among countries outside the US.

To predict possible possible traffic on the Internet network, we combine both the information about NSFNET traffic history and history of total host counts in the world and the host counts by country. NSFNET time series data explains the partial world traffic that goes through the NSFNET backbone only. This time series data extends until the beginning of 1995, which does not fully reflect the recent exponential growth in internet traffic due to the revised architecture of NSFNET and the development of other commercial backbones. Any prediction of total traffic based on this time series might be downward biased. Therefore, we use the time series data of the total number of hosts for different countries, which is available until recent months to capture the recent trends in Internet use. Based on the time series data, we predict the expected future number of hosts. An estimate of traffic per host and possible growth rate of traffic per host is obtained using historical information about traffic and hosts related to NSFNET. The information is then combined with the predicted host numbers to extrapolate some lower bound of the possible future traffic flow among different countries around the world.

4. ESTIMATION RESULTS

The model first estimates the average monthly traffic flow among seven different regions in the 4th quarter of 1994, shown in Table 1. For simplicity, we assume that the relative structure of the traffic flow among different regions is unchanged in the near future and that the demand for Internet access is growing at the same rate in all countries. Based on these assumptions and our model, we predict the future flow of traffic among the seven regions, distinguishing between the domestic and the international traffic. Predicted traffic flow for January 1998, January 1999, January 2000 and January 2003 are summarized in Table 2 to Table 5 respectively. These tables report the domestic and international traffic separately for each region. Figures in the tables also distinguish between inbound and outbound international traffic. However, our model could not distinguish between the inbound and outbound traffic within the domestic arena. The total inbound and outbound traffic for each region, which are shown on the marginal row and column of each table, include total domestic traffic in it. Therefore, inbound and outbound international traffic for each region could be obtained by subtracting the estimated domestic traffic of each region from its column sum or row sum respectively. The total traffic for any region could be obtained by adding domestic traffic and total international traffic (inbound + outbound).

It is a unique characteristic of Internet usage that the inbound and outbound traffic of any user need not be symmetric. This distinction is not made in traditional telephone traffic. Any analysis of Internet usage must incorporate this asymmetric behavior into the model. Our model takes this asymmetric behavior into account and allows us to predict the inbound and outbound traffic of different countries more rationally. Table 1 shows that the average monthly traffic of seven regions in 4^{th} quarter of 1994 was about 26.3 trillion bytes (traffic outside the NSFNET is an estimate). If we compare this figure with our model prediction, we observe that the average monthly traffic in January 2000 will be about 985 trillion bytes (shown in table 4), which is about 37.5 times larger than what it was in 4^{th} quarter of 1994. In January 2003, average monthly traffic will be about 3,459 trillion bytes (shown in table 5) with North America, Australia and Europe being the major players [2]. Figure 2 shows the forecasting of the total world Internet traffic.

5. CONCLUSION

[2] We could not directly validate our traffic forecast because information available for actual traffic is incomplete. However, we validated our host prediction based on available data (Network Wizard, RIPE) and our model predicts the future very well.

Several benefits can be obtained from the global network demand model developed in this paper. First the prediction from our model provides a macro-level picture of Internet traffic and helps estimate the future bandwidth needs around the world. Second, because of the direct link between the flow of international and domestic traffic, it helps us understand the future need for domestic bandwidth capacity to complete all international traffic movement efficiently. Third, the externality argument allows us to explain the asymmetric traffic flow between two countries often observed in the empirical data.

For further research, there are several areas to explore. In our estimation, due to the lack of country specific time series data for the number of hosts, we assume identical growth rate of hosts for each country. Depending on the status of the Internet users and the information industry infrastructure, each country is likely to have different growth rates for number of hosts. Due to this assumption, the nature of inbound and outbound traffic of different regions observed in 1994 remains unchanged in 2003. Once we relax this assumption in future with a rich data set and incorporate the country specific growth rate of hosts into our model, the nature of the asymmetry between inbound and outbound traffic between different regions will evolve over time. This important dynamic is missing in our current study. Of course, with the data available, the model is capable of showing the dynamics. We also need to extend the current model to be able to predict the future possible traffic flow that could be generated by new countries using the Internet network. Consideration of language and cultural aspects of different countries in the model would be very interesting. Also, based on the Internet traffic forecasts from this model, a model development for the network capacity plan would be very useful.

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Table 1: Average Monthly Internet Traffic in fourth quarter of 1994 (Billion bytes)

	US	**Australia**	**Europe**	**Canada**	**Asia**	**S. America**	**Africa**	**Total Outbound**
US	**10,919.38**	319.05	2963.09	528.91	748.16	97.63	87.90	15,664.12
Australia	208.65	**26.38**	23.11	13.62	16.77	4.96	4.57	298.06
Europe	775.11	163.74	**1,323.66**	173.37	261.82	41.90	38.08	2,777.68
Canada	34.51	14.54	26.13	**30.07**	18.66	5.36	4.94	134.21
Asia	173.58	29.30	64.56	30.53	**80.47**	9.42	8.63	396.49
S. America	24.59	1.15	1.37	1.16	1.25	**1.42**	0.67	31.61
Africa	22.87	0.96	1.13	0.97	1.04	0.61	**1.16**	28.74
Total Inbound	12,158.69	555.12	4,403.05	778.63	1,128.17	161.30	145.95	**19,330.91**

	US vs. other	**Australia vs. other**	**Europe vs. other**	**Canada vs. other**	**Asia vs. other**	**S. America vs. other**	**Africa vs. other**	**Grand Total**
Total Traffic (billion bytes)	16,903.43	826.80	5,857.07	882.77	1,444.19	191.49	173.53	26,279.28

Table 2: Average Monthly Internet Traffic in January of 1998 (Billion bytes)

	US	**Australia**	**Europe**	**Canada**	**Asia**	**S. America**	**Africa**	**Total Outbound**
US	**95,006.25**	2,775.96	25,780.96	4,601.89	6,509.52	849.45	764.79	136,288.81
Australia	1,815.40	**229.52**	201.07	118.50	145.91	43.16	39.76	2,593.33
Europe	6,744.00	1,424.65	**11,516.77**	1,508.44	2,278.02	364.56	331.32	2,4167.76
Canada	300.26	126.51	227.35	**261.63**	162.36	46.64	42.98	1,167.72
Asia	1,510.27	254.93	561.72	265.63	**700.15**	81.96	75.09	3,449.74
S. America	213.95	10.01	11.92	10.09	10.88	**12.35**	5.83	275.03
Africa	198.99	8.35	9.83	8.44	9.05	5.31	**10.09**	250.06
Total Inbound	105,789.11	4,829.93	38,309.62	6,774.63	9,815.87	1,403.42	1,269.87	**168,192.45**

	US vs. other	**Australia vs. other**	**Europe vs. other**	**Canada vs. other**	**Asia vs. other**	**S. America vs. other**	**Africa vs. other**	**Grand Total**
Total Traffic (billion bytes)	147,071.67	7,193.74	50,960.61	7,680.72	12,565.46	1,666.10	1,509.83	228,648.13

Table 3: Average Monthly Internet Traffic in January of 1999 (Billion bytes)

	US	Australia	Europe	Canada	Asia	S. America	Africa	Total Outbound
US	**215,170.75**	6,287.01	58,388.87	10,422.38	14,742.79	1,923.84	1,732.10	308,667.75
Australia	4,111.53	**519.83**	455.39	268.39	330.46	97.74	90.05	5,873.39
Europe	15,273.85	3,226.56	**26,083.25**	3,416.33	5,159.27	825.66	750.38	54,735.30
Canada	680.03	286.52	514.90	**592.54**	367.70	105.62	97.34	2,644.66
Asia	3,420.46	577.37	1,272.18	601.61	**1,585.69**	185.62	170.06	7,812.99
S. America	484.56	22.66	27.00	22.86	24.63	**27.98**	13.20	622.89
Africa	450.66	18.92	22.27	19.11	20.49	12.02	**22.86**	566.33
Total Inbound	239,591.85	10,938.86	86,763.86	15,343.22	22,231.04	3,178.48	2,876.00	**380,923.31**

	US vs. other	Australia vs. other	Europe vs. other	Canada vs. other	Asia vs. other	S. America vs. other	Africa vs. other	Grand Total
Total Traffic (billion bytes)	333,088.85	16,292.42	115,415.91	17,395.34	28,458.34	3,773.39	3,419.48	517,843.72

Table 4: Average Monthly Internet Traffic in January of 2000 (Billion bytes)

	US	**Australia**	**Europe**	**Canada**	**Asia**	**S. America**	**Africa**	**Total Outbound**
US	**409,471.29**	11,964.22	111,114.39	19,833.86	28,055.63	3,661.08	3,296.21	587,396.67
Australia	7,824.27	**989.24**	866.61	510.74	628.87	186.00	171.37	11,177.10
Europe	29,066.24	6,140.17	**49,636.59**	6,501.29	9,818.12	1,571.23	1,427.98	104,161.61
Canada	1,294.11	545.24	979.86	**1,127.61**	699.74	201.00	185.25	5,032.81
Asia	6,509.16	1,098.74	2,420.97	1,144.86	**3,017.58**	353.25	323.62	14,868.18
S. America	922.11	43.12	51.37	43.50	46.87	**53.25**	25.12	1,185.36
Africa	857.61	36.00	42.37	36.37	39.00	22.87	**43.50**	1,077.74
Total Inbound	455,944.80	20,816.72	165,112.17	29,198.24	42,305.81	6,048.67	5,473.05	**724,899.46**

	US vs. other	**Australia vs. other**	**Europe vs. other**	**Canada vs. other**	**Asia vs. other**	**S. America vs. other**	**Africa vs. other**	**Grand Total**
Total Traffic (billion bytes)	633,870.17	31,004.59	219,637.20	33,103.43	54,156.40	7,180.78	6,507.29	985,459.86

Table 5: Average Monthly Internet Traffic in January of 2003 (Billion bytes)

	US	**Australia**	**Europe**	**Canada**	**Asia**	**S. America**	**Africa**	**Total Outbound**
US	**1,437,184.77**	41,992.66	389,995.39	69,613.97	98,471.17	12,849.20	11,569.20	2,061,677.01
Australia	27,462.05	**3,472.08**	3,041.69	1,792.63	2,207.23	652.82	601.49	39,230.00
Europe	102,018.27	21,551.10	**174,217.22**	22,818.58	34,460.17	5,514.79	5,012.01	365,592.13
Canada	4,542.13	1,913.72	3,439.17	**3,957.75**	2,455.99	705.47	650.19	17,664.42
Asia	22,846.22	3,856.40	8,497.25	4,018.29	**10,591.28**	1,239.84	1,135.86	52,185.14
S. America	3,236.48	151.36	180.32	152.68	164.52	**186.90**	88.18	4,160.44
Africa	3010.10	126.35	148.73	127.67	136.88	80.29	**152.68**	3782.70
Total Inbound	1,600,300.03	73,063.67	579,519.75	102,481.57	148,487.25	21,229.95	19,209.62	**2,544,291.85**

	US vs. other	**Australia vs. other**	**Europe vs. other**	**Canada vs. other**	**Asia vs. other**	**S. America vs. other**	**Africa vs. other**	**Grand Total**
Total Traffic (billion bytes)	2,224,792.27	10,8821.60	770,894.67	116,188.25	190,081.11	25,203.49	22,839.64	3,458,821.02

Figure 1: Traffic Estimation

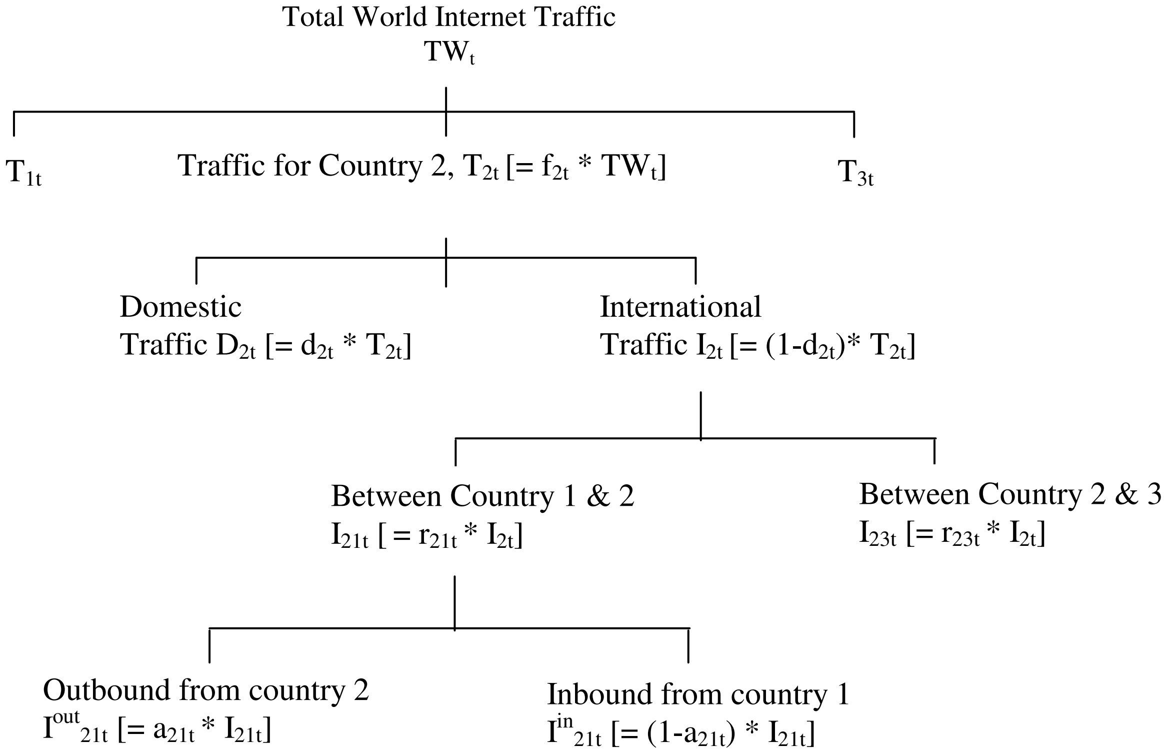
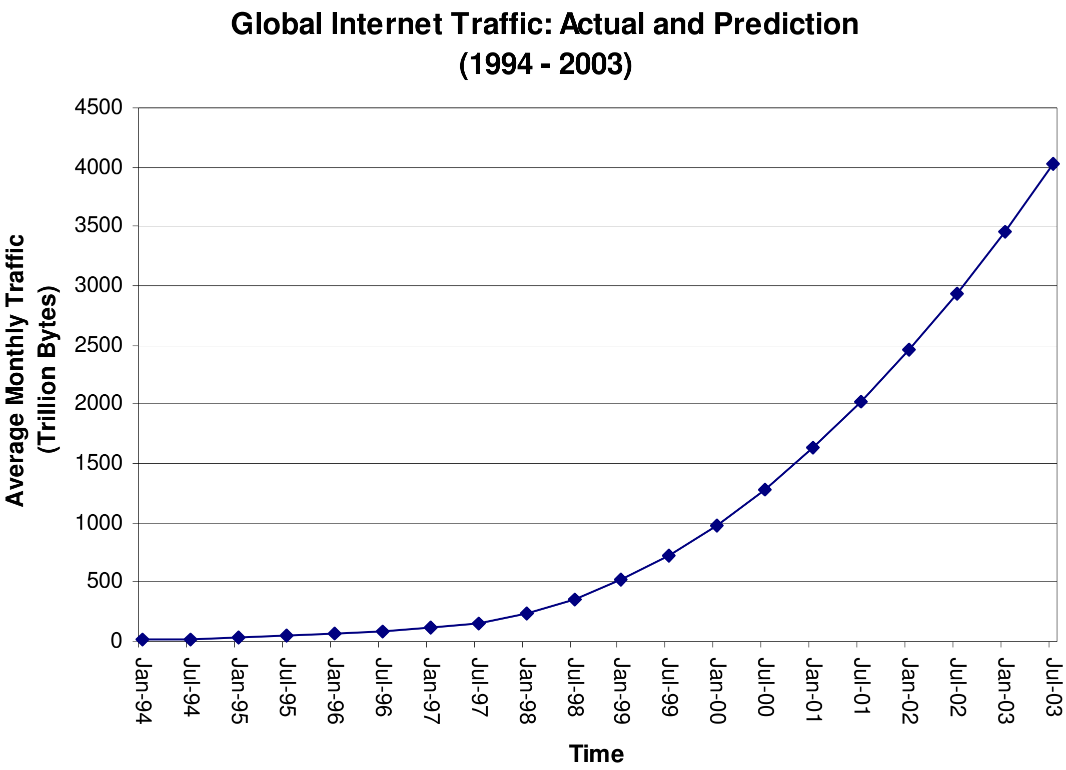


Figure 2


Global Internet Traffic: Actual and Prediction
(1994 - 2003)
Average Monthly Traffic
(Trillion Bytes)
4500
4000
3500
3000
2500
2000
1500
1000
500
0
Jan-94
Jul-94
Jan-95
Jul-95
Jan-96
Jul-96
Jan-97
Jul-97
Jan-98
Jul-98
Jan-99
Jul-99
Jan-00
Jul-00
Jan-01
Jul-01
Jan-02
Jul-02
Jan-03
Jul-03
Time