# Distributed Internet Traffic Generator (D-ITG): analysis and experimentation over heterogeneous networks

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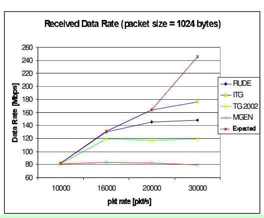
## 1- Traffic Theory

• Modeling the *Internet Traffic* is an important and essential task and we think that traffic theory should be increasingly used to guide the design of the future ***multi-service, integrated and heterogeneous Internet***.
• It is unlikely that we will be able to understand the traffic characteristics, predict network performance (Quality of Service (***QoS***), Service Level Agreements (***SLAs***) definition, …), or design dimensioning tools without analytical and rigorous models.
•Since demand is random in nature, appropriate modeling theories and tools need to make use of the theory of stochastic processes.

## 2- Why a new traffic generator ?

• One of the applications of traffic models is the generation of synthetic, yet realistic traffic to be injected into a network, in order to simulate the behavior of a multitude of real traffic sources. In the case of studies related to the Internet, simulations should reflect not only the wide scale of real scenarios, but also the rich variety of traffic sources, in terms both of protocol typologies and of data generation patterns.
• The purpose of our ***Distributed Internet Traffic Generator (D-ITG)*** is to build up a suite that can be easily used to generate repeatable sets of experiments by using a reliable and realistic mixture of available traffic typologies.
•The generation of realistic traffic patterns helps in studying protocols and applications of interest in today's Internet. D-ITG can generate ***UDP*** and ***TCP*** traffic and is designed for the generation of ***"layer 7" traffic*** (application layer traffic).
•D-ITG primary design goals are:
1 - refine and validate modeling techniques derived from theory: both implementation and use of a traffic generator permit the analysis and validation of theoretical assumptions;
2 - reproducibility of network experiments: we implemented a method that can use the same seed for different stochastic experiments. It is possible to reproduce experiments by choosing the same seed value for the *packets inter-departure* and *packets size* random processes ;
3 - investigation of scaling effects: using different network loads or different network configurations is possible to study scalability problems;
4 - increase the generation performance with respect to existing Traffic Generators;
5 - increase the available traffic source models with respect to other Traffic Generators;
6 - the possibility of simulating more complex traffic sources, repeating many times exactly the same traffic pattern (not only its mean value) and getting information not only about received packets but also about transmitted packets;
7 - measuring the round trip time and one way delay.

• We believe that D-ITG shows interesting properties when compared to other traffic generators. We implemented a centralized version and two kinds of distributed generators.
• In the first distributed version there is a log server that is used by senders and receivers for data logging (both communication between senders → log server and receiver → log server are carried out using an UDP communication).




• In the second distributed version, processes of both senders and receivers have been implemented using MPI library.
• Distributed versions present a better performance with respect to centralized version. By separating generation and log processes, we eliminated the interference problem between them, which results in better overall performance.
• To our knowledge, no similar works are available. The figure above shows a comparison among our D-ITG and other largely used traffic generators.

## 3- Results from D-ITG

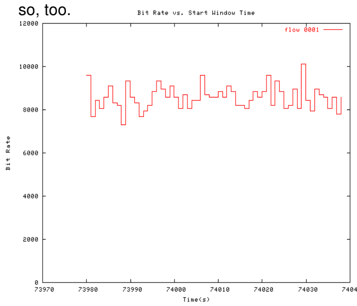
• Typically other traffic generators can generate only UDP traffic with limited generation performance and offer a limited set of random variable distributions.
• D-ITG implements both TCP and UDP traffic generation according to several probability distributions (*exponential, uniform, constant, pareto, cauchy, normal, …*) both for ***IDT (Inter Departure Times)*** and ***PS (Packet Size)*** random variables. Our D-ITG allows to reproduce very complex network conditions under different network traffic loads and configurations.

• For example, using the following command on the PCSender:

```
./ITGsend -a PCReceiver -l send -t 60000 -T TCP -V 3 10 -c 16
```

**1 -** This command tells to the sender to generate one flow addressed to the host named PCReceiver with TCP (-T option) transport protocol.
**2 -** The flow lasts 60 seconds (-t option) and packet generation process is a pareto process (-v option), characterized by shape equal to 3 and scale equal to 10. We want to calculate now the expected average bit rate, in order to verify the accuracy of our D-ITG.
**3 -** First, we note that utilities we used consider only the payload size of packets (and not their full size) in determining the average bit rate, and we will do so, too.

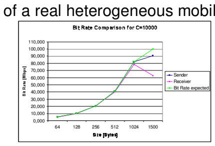
```
Num pkts recvd   :  4010
Join delay       : 73979.945 sec
Recv pkt rate    :     66.939 pkt/sec
Recv data rate   :      8.570 kbps
Pkts dropped     :      0
Ave. Tx Delay    :      0.000 sec
Max. Tx Delay    :      0.000 sec
Min. Tx Delay    :      0.000 sec
Delay variation  :      0.000 sec
```




**4 -** The mean of a Pareto random variable having the above defined parameters is equal to 15, this means that the average time interval between the departure of two consecutive packets is 15 msecs; the payload size is 16 bytes. Therefore the average bit rate is equal to the ratio between 128 bits and 15 msecs, which yields 8,533Kbps. The output and resulting plots derived from the log file of PCsender confirm our expectations.

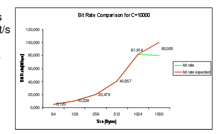
## 4- Using D-ITG in heterogeneous mobile scenario

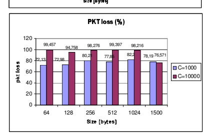
• D-ITG has been ported on PDA platform where is running the Linux FAMILIAR – kernel 2.4.18 version. Using this implementation is possible to carry out a complete characterization of a real heterogeneous mobile network.




UDP analysis for 10000 pkt/s with several packets size.

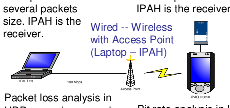

TCP analysis for 10000 pkt/s with several packets size.

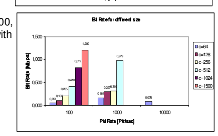


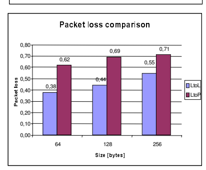




UDP analysis both for 10000 and 1000 pkt/s with several packets size. IPAH is the receiver.

TCP analysis for 10000, 1000 and 100 pkt/s with several packets size. IPAH is the receiver.

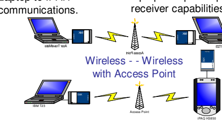


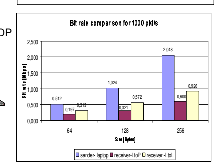



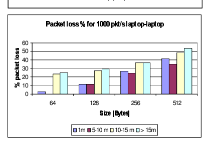




Packet loss analysis in UDP scenario comparing Laptop to Laptop and Laptop to IPAH communications.

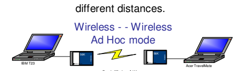
Bit rate analysis in UDP scenario: comparing laptop and palmtop receiver capabilities.

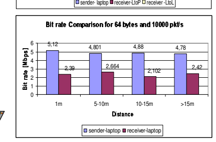


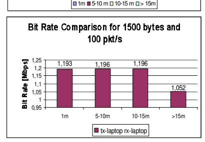




Packet loss and bit rate analysis in UDP scenario comparing Laptop to Laptop ad hoc mode communications with mobile users at different distances.




Bit rate analysis in TCP scenario comparing Laptop to Laptop ad hoc mode communications for 100 pkt/s of 1500 bytes.

• The results shown in this poster can be used as reference scenarios for development of wireless communication applications.
• D-ITG enables performance evaluation of ***heterogeneous devices*** (Laptop, PC desktop, IPAH, …) over ***heterogeneous networks*** (Wired LAN, WLAN, …).

## 5- Conclusions and Issues for Research

• *Conclusions:*
• Both the tutorials presented at SIGCOMM 2003 [2] and at MMNS 2003 [3] have shown that Internet traffic patterns and models are particularly interesting for networking research community. This poster shows an innovative and powerful software architecture capable to reproduce real "Internet Traffic". D-ITG is useful in order to characterize heterogeneous mobile networks.
• *Future work:*
• How to configure next generation networks (NGNs) when more complex traffic bundle rely on it ? Extending this work to include both all "layer 4-7" (VoD, VoIP, FTP, Telnet, HTTP, DNS, SNMP, …) traffic generation and ICMP could be interesting.
• Presently, our network allows experiments on a small-scale. We would test D-ITG on networks of a much ***wider-scale***.
• Mobile Internet access using WLAN and GPRS/3G has gained good popularity. We would test D-ITG in a more large heterogeneous environment made by both heterogeneous (wired and wireless) networks (WLAN, Bluetooth, UMTS, GPRS, GSM,..) and heterogeneous users' devices (Laptop, PDA, Advanced Mobile Phone, Workstation,…).

## References

[1] *A. Pescapè, M. D'Arienzo, S. P. Romano, M. Esposito, S. Avallone, G. Ventre, "Mtools" - IEEE Network – Software Tools for Networking - September/October 2002, Vol. 16 No. 5 pag. 3. ISSN 0890-80445*
*[2] John Doyle and Walter Willinger, "10 Years of Self-Similar Traffic Research: A Circuitous Route Towards a Theoretical Foundation for the Internet", Tutorial 2 at SIGCOMM 2003 Conference*
*[3] Petre Dini, "Internet Multimedia Traffic Patterns", Tutorial 3 at MMNS 2003 Conference*

## Acknowledgement

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