Measuring Heterogeneous Wireless Networks

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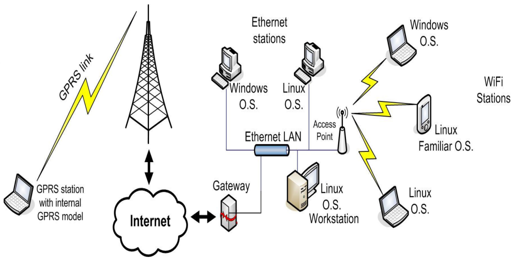
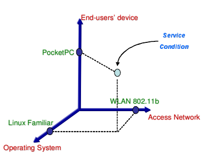
1- Measuring Heterogeneous Wireless Networks

• Packet loss, delay and jitter degrade the quality of services like VoIP (Voice over IP) or Video Streaming over IP networks. In real networks, an experimental measure of these parameters is fundamental in the planning process of new services over novel network infrastructures.

• Currently networks are heterogeneous in terms of access network technologies, end users' devices, Operating Systems and finally end-users' application.



• We introduce a network performance methodology dividing our experimentation on several traffic classes.



• We measure TCP and UDP performance (in terms of QoS (*Quality of Service*) parameters like throughput, delay (OWD and RTT), jitter and packet loss) in more than network scenario (that we called "*Service Condition*") where there is interoperability among

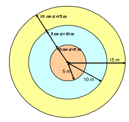
• different network technologies (*Ethernet, Fast Ethernet, Giga Ethernet, xDSL, WLANs 802.11b, Bluetooth, GSM, GPRS, UMTS*);
• different end-user devices (*Palmtop, Laptop, PC desktop*);
• different operating systems (*Unix, Linux, Win 98/NT/2000/XP, Win CE, Linux Familiar, Embedded OS, Symbian, ...*);
• different user applications with different QoS traffic requirements.

• The performance evaluation study has been performed following the indication of IP Performance Metrics (IPPM) IETF Working Group [1].

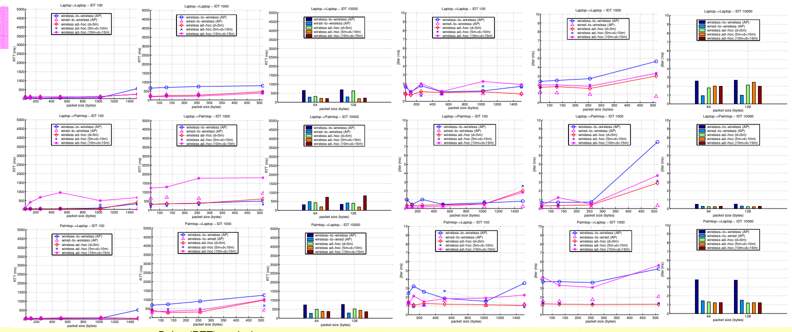
• The network behavior has been studied introducing an innovative synthetic traffic generator that we called DITG (*Distributed Internet Traffic Generator*) [2] and which provides a set of powerful tools for traffic patterns generation over heterogeneous wireless networks and results analysis.

• We present our experimental results and at the same time we analyze and compare our results with respect to theoretical assumptions on wireless performance behavior carried out in [3].

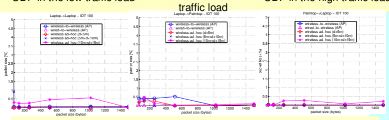
• In the case of an ad-hoc scenario, we have experimented more configurations, allowing the two communicating hosts to move at various mutual distances: we tested a mobile environment using roaming user in three classes of end2end mutual distances ($d < 5$ *m*, 5 *m* $< d <$ 10 *m*, 10 *m* $< d <$ 15 *m*).



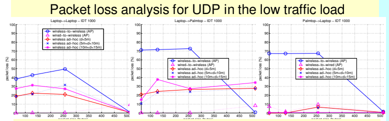
• In our measurement framework, the measures are organized such that to distinguish three types of traffic conditions:
• *low* traffic load (≤ 1.2 *Mbps*): in our scenario *low* traffic load means a traffic state in which we are far from the saturated wireless channel condition.
• *medium* traffic load (≤ 4.0 *Mbps*): for *medium* traffic load we mean a traffic state in which we are close to the saturated wireless channel condition.
• *high* traffic load (≤ 10 *Mbps*): in the case of *high* traffic load we have a traffic state in which we are in the saturated wireless channel condition (i.e. every station has always a packet ready for the transmission).



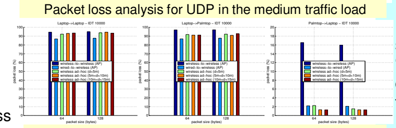
Delay (RTT) analysis for UDP in the low traffic load | Delay (RTT) analysis for UDP in the medium traffic load | Delay (RTT) analysis for UDP in the high traffic load | Jitter analysis for UDP in the low traffic load | Jitter analysis for UDP in the medium traffic load | Jitter analysis for UDP in the high traffic load



Packet loss analysis for UDP in the low traffic load



Packet loss analysis for UDP in the medium traffic load

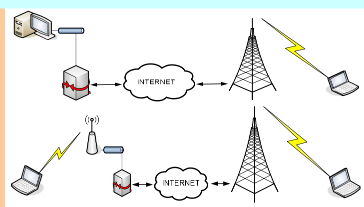


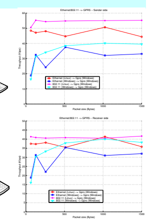
Packet loss analysis for UDP in the high traffic load

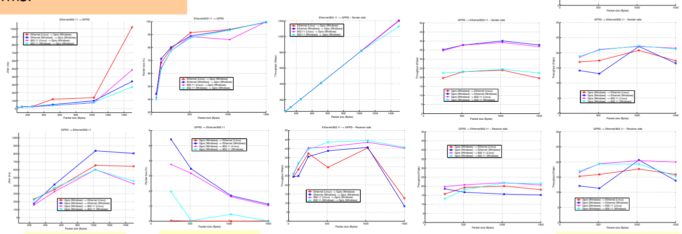
• For each measured parameter, several trials have been performed in the same operating conditions. The values reported in the graphics present in the poster represent a mean value across twenty test repetitions.
• Achieved results highlight the dependencies with (i) a high heterogeneity level, (ii) the properties of Palmtop device and (iii) three different traffic classes made by several combinations of IDTs and PSs.
• Furthermore, we present the TCP performance over wireless link varying the "*application level*" packet size: thanks to this "*modus operandi*" we can simple highlight which is the real TCP behavior over heterogeneous wireless network for different packet size values. Comparing the behavior for the same "*application level*" packet size, our analysis permits to clarify the conditions in which TCP performs better than UDP. We think that this result is particularly interesting when compared with other previous works.

• Furthermore, our results have been analyzed with respect to analytical model provided by Bianchi. We have demonstrated that it is useful as an upper bound, but in a real scenario and from the application point of view a tuning of the Bianchi model parameters could be useful: we are working on a revised analytical modeling of Bianchi proposal in order to take into account results shown in this poster.

• In the case of network scenario where GPRS networks are present, we taken into account only the low traffic condition load situation.
• We considered the communications between GPRS and Ethernet and GRPS and 802.11 (in the case of UDP and TCP) over both Windows and Linux platforms.

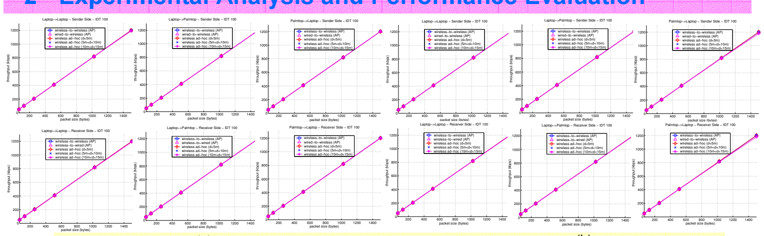




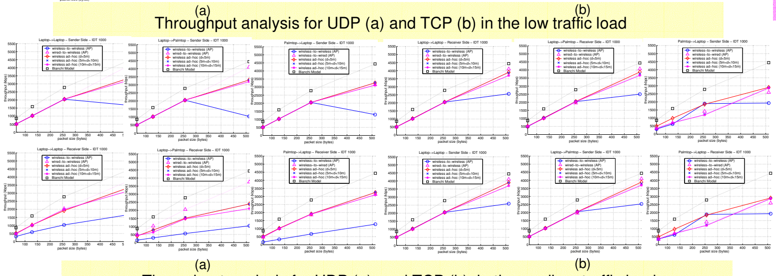


UDP Jitter analysis | UDP Packet Loss analysis | UDP Throughput analysis | TCP Throughput analysis

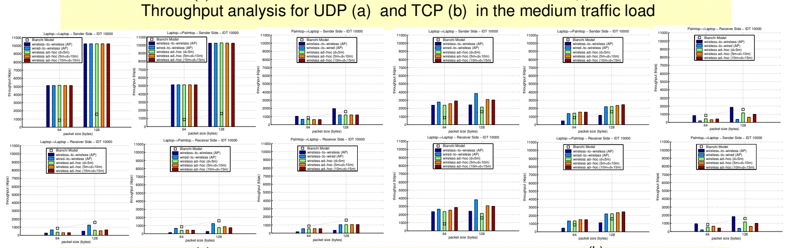
2 - Experimental Analysis and Performance Evaluation



(a) (b)
Throughput analysis for UDP (a) and TCP (b) in the low traffic load



(a) (b)
Throughput analysis for UDP (a) and TCP (b) in the medium traffic load



(a) (b)
Throughput analysis for UDP (a) and TCP (b) in the high traffic load

3 - Conclusions and Issues for Research

• We are moving toward an "*application level Bianchi*" model.
• In the meanwhile, results showed in this poster can be used as references for development of wireless communication applications. Indeed in a planning phase of innovative applications over heterogeneous networks is necessary a complete parametric network characterization.

• In our ongoing work, we are studying which are the dependencies between experimented performance and different traffic patterns.
• Finally, we believe that a complete analysis (from the physical layer to the application layer) is needed, but in a first approximation where a performance analysis is necessary for characterizing end-users application over heterogeneous network, our approach is exceptionally important.
• An interesting second step could be a deep analysis in order to understand which is the relationship between measured performance at application/transport layer and modeled/measured performance at physical/data link layer.

References

[1] IP Performance Metrics (IPPM), IETF Working Group http://www.ietf.org/html.charters/ippm-charter.html
[2] A. Pescapè, S. Avallone, D. Emma, "D-ITG, Distributed Internet Traffic Generator" http://www.grid.unina.it/software/ITG
[3] G. Bianchi, "Performance Analysis of the 802.11 Distributed Coordination Function", Selected Area in Communications, IEEE Journal on Volume: 18 Issue: 3, March 2000 Page(s): 535 -547

Acknowledgement

This work has been carried out partially under the financial support of the Ministero dell'Istruzione, dell'Università e della Ricerca (MIUR) in the framework of the FIRB Project "Middleware for advanced services over large-scale, wired-wireless distributed systems (WEB-MINDS)".