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Indirizzo di Elettronica e Telecomunicazioni
XXI ciclo

ATTIVITA' DI FORMAZIONE

Corsi specifici per studenti di Dottorato offerti presso l'Università di Padova:

- “Applied linear algebra”, Prof. T. Damn (superato)
- “Techniques for Effective Transmission of Multimedia Signals”, Prof G.A. Mian (superato)
- “Introduction to Computer Graphics”, Prof A. Fusiello (superato)
- “Renewal and Semi-Markov Random Processes and their Application to Network Protocol Analysis”, Prof. M. Zorzi (superato)
- “Data Structures, Analysis of Algorithms and Data Compression”, Prof R. Giancarlo (superato)
- “Statistical Method”, Prof L. Finesso (superato)
- “Applied Functional Analysis”, Prof P. Ciatti (superato)
- “Wireless Underwater Communications - A short Course,” Prof. M. Stojanovic (solo seguito)

Partecipazione a scuole:

- Summer School on Information Engineering, 26-30 June, 2006, Brixen, Italy

Altri seminari seguiti:

- “Wireless Underwater Communications and Networks: Current Achievements and Future Research Challenges,” author M. Stojanovic
- “Security and IP-based 3G Wireless Networks” author T. F. La Porta
- “IP mobility and effects of mobility on TCP” author T. F. La Porta
- “Free-Space Optical Networks: Some Capacity Considerations” author A. S. Acampora
- “At the Forefront of Modern Telecommunications” author A. Acampora
- “Optimistic Parallelization using the Galois System” author K. Pingali
- “From wireless networks to sensor networks and onward to networked embedded control” author P.R. Kumar
- “Intelligent Sensor Networks - The role of messaging middleware for end-to end business solutions” author P. R. Chevillat
- “On cross-layer design of MIMO ad hoc networks” author P. Casari
- “Cross-layer design in wireless data networks: concepts and application examples” author S. Merlin
- “Overhaul of IEEE 802.11 Modeling and Simulation in NS-2” authors D. Jiang and F. Schmidt-Eisenlohr
- “Evolutionary algorithm techniques for network optimization problems” author A. Botta

Periodi di Attività all'Estero:

Da Novembre 2007 a Marzo 2008 presso INRIA, Sophia Antipolis, Francia.

Didattica Attiva (lezioni, esercitazioni, laboratori)

Lezioni:

5 ore di didattica di supporto tenuta all'interno del corso di *Internet e laboratorio di reti di telecomunicazioni*, prof. Zorzi, corso di laurea specialistica in Ingegneria delle Telecomunicazioni, A.A. 2006/07. Argomenti trattati: “Tecniche di simulazione per l’analisi delle prestazioni dei sistemi”

Supervisione tesi:

- Correlatore della tesi “Analisi di protocolli di instradamento per reti ibride MANET-UMTS” di Leonardo Bressan, corso di laurea specialistica in Ingegneria delle Telecomunicazioni, A.A. 2004/2005
- Correlatore della tesi “Progettazione e sviluppo di un modulo NS-2 per Power Saving in Wireless LAN” di Gianluca Pometto, corso di laurea specialistica in Ingegneria Informatica, A.A. 2005/06
- Correlatore della tesi “Analisi e implementazione di un algoritmo di Call Admission Control per VoIP su reti MANET con gateway” di A. Magarotto, corso di laurea specialistica in Ingegneria delle Telecomunicazioni, A.A. 2006/2007
- Correlatore della tesi “Progettazione ed analisi di un algoritmo di call admission control su reti mesh” di G. Ursino, corso di laurea specialistica in Ingegneria delle Telecomunicazioni, A.A. 2006/2007
- Correlatore della tesi “Valutazione dell’impatto di tecniche di sicurezza sulle strategie di ottimizzazione per comunicazioni VoIP su WLAN” di M. Scarpa, corso di laurea triennale in Ingegneria delle Telecomunicazioni A.A. 2007/2007
- Correlatore della tesi “Studio di Schemi Efficienti per la Trasmissione di Flussi Dati Multilivello su Reti con Perdite” author M. Bonini, corso di laurea specialistica in Ingegneria delle Telecomunicazioni, A.A. 2006/2007

ATTIVITA' DI RICERCA

Optimization of Voice-over-IP-over WiFi in ad hoc and infrastructure networks

This research activity was mainly carried out as part of the collaboration between the SIGNET research group at DEI and TILab (TelecomItalia Labs), Torino.

The main issues in the transmission of VoIP over an infrastructured network are the study of the maximum number of voice calls which the network can support (voice capacity) and the perceived speech quality. In such a scenario, the research challenge is to find optimization techniques able to improve the maximum number of sustainable voice calls and the perceived voice quality (QoS). By exploiting the ad hoc capability, hybrid nodes (terminals which have both the WiFi and UMTS interfaces) can be used for relaying data connections and thus increasing the coverage range. The main issue in transmitting voice over ad hoc networks is the impact of routing algorithms on the speech quality. In fact, due to the time variance of its topology, routes may change during a voice call.

The research activity has been then addressed to the evaluation of the voice capacity of infrastructure and ad hoc WiFi networks and to the optimization of the routing algorithms in order to select the best route to the gateway and to compensate the time variance of the topology.

The activity has led to the following results.

1) *Voice capacity of infrastructure WiFi networks and a multi-hop ad hoc network:*

We devised a simple though effective analytical formula to estimate the voice capacity in both infrastructure and multi-hop IEEE 802.11 networks. The estimate turned out to be fairly accurate, though it slightly overestimates the number of admissible connections because the collision probability is not considered. In addition, we have observed that the bottleneck of the system is the downlink, because the medium access mechanism approximates, by its nature, a max-min fair sharing of the channel occupancy time among all the competing stations, which is detrimental in case of balanced flows since the Access Point needs to forward the downlink traffic for all the active connections. In the second step of the analysis, we evaluated the impact of multi-hop paths on the voice capacity of the system, reaching the conclusion that voice connections cannot be supported over long multi-hop paths.

Different conclusions, however, were drawn when considering ad hoc networks. In fact we observed that downlink and uplink flows experience comparable performance. The motivation is that nodes that belong to uplink multi-hop paths need to forward the traffic received by all the tributaries paths, so that they can rapidly exhaust their channel-time share.

2) Optimized routing algorithm for VoIP over multi-hop WiFi networks

We found that, to increase the system capacity, we need to minimize the length of the paths and the number of overlapping paths. On the basis of such intuition, we propose a novel hybrid routing protocol, HOLSR, which selects the path that minimizes the hop count, first, and the on-air transmission time as a second choice. By simulation, we showed that HOLSR is able to maintain the system stability when other routing algorithms fail.

Cross-layer optimization for WLAN

This research activity was carried out as part of the collaboration between the SIGNET group and the AST group of STMicroelectronics, Agrate Brianza, Italy.

The objective of this study was to identify suitable optimization techniques for Wireless LAN networks based on the 802.11b/g protocol. The following issues have been analyzed:

Network Status Estimation: the performance of 802.11 communications depends on several aspects such as the propagation conditions, the number of nodes contending for the channel, and the type of traffic injected by each node into the network. We defined the Network Status as a set of variables which enable a complete and meaningful representation of all these aspects. We also designed practical schemes for estimating the Network Status within real devices. The resulting Network Status Estimator has been validated with respect to well-known analytical models by means of extensive simulations. The Network Status Estimator is currently being used as a key component in all research activities related to cross-layer optimization for WLAN carried out in our group.

Goodput-Optimal Rate Adaptation for 802.11: in this activity we considered the problem of adapting the PHY rate of an 802.11 station in order to maximize the link-layer throughput.

Rate Adaptation for 802.11 has been deeply investigated in the past, but the problem of achieving optimal Rate Adaptation with respect not only to channel-related errors but also to contention-related issues (i.e., collisions and variations in medium access times) is still unsolved. We addressed this issue by developing an analytical model of the goodput performance as a function of the Network Status described earlier; this analytical model has been used to develop a rate adaptation algorithm, called Goodput Optimal Rate Adaptation (GORA). Conversely to other Rate Adaptation schemes proposed in the literature, which require either modifications to the IEEE 802.11 standard or cooperation among nodes, GORA is totally stand-alone and standard compliant.

The performance of GORA has been evaluated by means of simulations. Results show that, as expected, GORA outperforms other well-known Rate Adaptation algorithms in several scenarios.

Adaptive Parameters Optimization Scheme for Voice over 802.11: we considered the problem of dynamically adapting the IEEE 802.11g parameters with the aim of enhancing the quality of a voice communication between a mobile station and a remote peer node.

The Network Status formulation discussed above was used to develop a mathematical model which allows the calculation of the expected end-to-end network performance in terms of throughput, delay and packet error rate, for different settings of some PHY and MAC parameters, such as the modulation/coding scheme and the retransmission limit. The setting that is estimated to maximize the quality of service for the end user is then selected. Performance evaluation of the proposed scheme has been carried out by means of simulations. The results show that the analytical model, even though based on some simplifying assumptions, leads to the selection of a configuration which effectively improves the end-user perceived service quality.

3D models over packet switching networks

The remote exploration of three-dimensional scenes is becoming a new Internet application. Our interest in this area was to design an efficient transport layer for 3D remote browsing. We proposed two Forward Error Correction (FEC) techniques, both based on the Unequal Error Protection (UEP) principle for the distribution of the redundancy among the different layers that compose the 3D scene. The former method minimizes the delay between the request of the view and the instant when the image begins to be shown in the monitor (although with low resolution). Using this method, if a layer cannot be reconstructed all packets that arrive after that layer are useless. The second approach resolves this problem since each packet has the same importance as all others, but the delay between the request of the view and the instant when the image begins to be rendered to the client side is increased. The two techniques have been mathematically modeled and analyzed, revealing that even a modest amount of redundancy can drastically improve the quality of the 3D scene browsing over lossy channel, provided that the redundancy is suitably distributed among the layers.

Network Simulation Tools

This activity is centered around the development of NS-Miracle, which is a set of libraries designed to enhance the functionalities provided by the Network Simulator ns-2. NS-Miracle provides an efficient and embedded engine for handling cross-layer messages and, at the same time, enables the coexistence of multiple modules within each layer of the protocol stack. For instance, multiple IP, link, MAC or physical layers can be specified and used within the same node, and can exchange arbitrary control information using cross-layer messages. In addition, dedicated modules and APIs provide an enhanced support for the development of PHY, MAC and Routing implementations. Overall, the NS-Miracle framework facilitates the simulation of modern communication systems in ns2; moreover, due to its modularity, the code is portable, re-usable and extensible. Finally, NS-Miracle also features detailed implementations of the 802.11, UMTS and WiMAX radio technologies, as well as a set of modules for the simulation of Underwater Acoustic Communications.

Another activity was addressed to the designed of Network Simulator version 3, the next generation of the popular NS2 platform. ns-3 is a new discrete-event network simulator designed for supporting network research and education. It features a solid, well documented C++ core and models for TCP/IP (IPv4), several link types including WiFi, and mobility models. ns-3 is an open source project released under the GNU GPLv2 license which allows anyone to use ns-3 without having to pay any license fee or royalties. My activity consisted in contributing to the design of the simulator core and to the realization of the first release.

Titolo definitivo Tesi: “Cross layer optimization in wireless networks”

Supervisore: prof. Michele Zorzi

Indice (provvisorio)

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 - 1.2. Multimedia over wireless links
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 - 2.1. Introduction
 - 2.2. Dynamic libraries
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3. Voice-flows over wireless networks
 - 3.1. Problem statement
 - 3.2. Survey of the literature
 - 3.3. Voice capacity of infrastructure IEEE 802.11 network
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 - 3.5. Optimization of the transport/routing layer
4. Multimedia over IEEE 802.11 links
 - 4.1. Problem statement
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5. 3D scene browsing over wireless channels
 - 5.1. Problem statement
 - 5.2. Survey of the literature
 - 5.2.1. 3D scene coding
 - 5.2.2. Unequal error protection techniques for erasure channels
 - 5.3. Definition and analysis of UEP schemes
 - 5.3.1. Horizontal scheme
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6. Conclusions
7. Appendix
 - 7.1. IEEE 802.11 standard: basics
 - 7.2. UMTS standard: basics

PUBBLICAZIONI E BREVETTI

Elenco brevetti internazionali

- ZANELLA A., ZORZI M, **MAGUOLO F**, Merlin S, Baldo N, Siorpaes, D, Melpignano D. "Cross layer optimization in multimedia communications", PCT/12/347,852
- ZANELLA A., ZORZI M, **MAGUOLO F**, Merlin S, Baldo N., Siorpaes, D, "LINK ADAPTATION IN WIRELESS NETWORKS", PCT/12/347,874
- ZANELLA A., ZORZI M, **MAGUOLO F**, FASOLO E, RUFFINO S, STUPAR P. (2006). "Method for routing in a local mobile communicaiton network." PCT/EP2006/010465. Telecom Italia S.p.A.

Elenco pubblicazioni su convegni internazionali

- N. Baldo, F. **Maguolo**, S. Merlin, A. Zanella, M. Zorzi, D. Melpignano, D. Siorpaes "GORA: Goodput Optimal Rate Adaption for 802.11 using Medium Status Estimation." In Proceedings of ICC 2008. Beijing, China. May 19-23
- N. Baldo, F. **Maguolo**, S. Merlin, A. Zanella, M. Zorzi, D. Melpignano, D. Siorpaes "APOS: Adaptive Parameters Optimization Scheme for Voice over IEEE 802.11g." In Proceedings of ICC 2008. Beijing, China. May 19-23 2008.
- E. Fasolo, F. **Maguolo**, A. Zanella, M. Zorzi, S. Ruffino, P. Stupar "VoIP Communications in Wireless Ad hoc Network with Gateways." in Proceedings of ISCC 2007. MediaWin 2007. Aveiro, Portugal. 1-4 July 2007.
- F. **Maguolo**, F. De Pellegrini, A. Zanella, M. Zorzi "Cross-Layer solutions to performance problems in VOIP over WLANS" in Proceedings of EUSIPCO, September 4-8, 2006 in Florence, Italy.
- F. De Pellegrini, F. **Maguolo**, A. Zanella, M. Zorzi, "A CrossLayer Solution for VoIP over IEEE802.11" in Proceedings of WPMC2005. September 18-22, 2005 in Aalborg, Denmark
- F. **Maguolo**, M. Lacage, T. Turletti, "Efficient Collision Detection for Auto Rate Fallback Algorithm", MediaWiN 2008
- N. Baldo, F. **Maguolo**, M. Miozzo, M. Rossi and M. Zorzi, "ns2-MIRACLE: a Modular Framework for Multi-Technology and Cross-Layer Support in Network Simulator 2

Lavori sottoposti

- Pietro Zanuttigh, Andrea Zanella, Guido M. Cortelazzo and Federico Maguolo, "Transmission of 3D scenes over lossy channels", SUBMITTED TO INTERNATIONAL JOURNAL OF DIGITAL MULTIMEDIA BROADCASTING [2009]