Networking RP @ DISI

Fabrizio Granelli, Lab Coordinator
Networking RP: Focus

Research Topics:
- Protocol Design and Architectures
- Network Design and Dimensioning
- Traffic Modeling
- Cross-layering
- Performance Evaluation
- Flow and Congestion Control
- Switching and Switches Architectures
- Timing and Synchronization
- Network Measurement

Application Areas:
- **Optical Networks**
  - Architectures, switching, transparent (all-optical)
  - Wide Area Networks and Backbone Design
  - Ultra-High Bandwidth Switching
- **Wireless Networks**
  - Scheduling, QoS and resource management
  - Wireless mesh networks: WiFi, WiMax
  - Cellular: transmission, protocols and network design
  - MAC protocols
  - Ad-Hoc and mobile
  - Cognitive Networks
- **Peer-to-peer**
  - Overlay construction and management
  - Distributed signaling
  - Overlay to network mapping and cooperation

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Networking RP: People

- **Faculties (5):**
  - Fabrizio GRANELLI
  - Renato LO CIGNO
  - Yoram OFEK
  - Luca ABENI
  - Alessandro ZORAT
  - Lab Coordinator
  - Associate Professor
  - Professor
  - Assistant Professor
  - Professor

- **PostDocs, Research Assistants (6):**
  - Csaba KIRALY
  - Dzmitry KLIAZOVICH
  - Jasvir NAGRA
  - Matteo NARDELLI
  - Amitabh SAXENA
  - Danilo SEVERINA
  - Research Assistant
  - PostDoc
  - PostDoc
  - Research Assistant
  - PostDoc
  - Research Assistant

- **PhD Students (7):**
  - Yury AUDZEVICH
  - Nadhir BEN HALIMA
  - Gianluca CICCARELLI
  - Michele ENDRICI
  - Christian FACCHINI
  - Troung Huong THU
  - Olga ZADEDYURINA
  - PhD Student
  - PhD Student
  - PhD Student
  - PhD Student
  - PhD Student
  - PhD Student

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Networking RP: Ongoing Projects

- Discreet (Discreet Service Provision in Smart Environment)
- Profiles (PeeR-to-peer beyOnd FILE Sharing)
- RE-TRUST (Remote EnTrusting by RUntime Software auThentication)
- WOMEN (Wireless 802.16 Multi-antenna Mesh Networks) → now WORLD (Wireless multiplatfOrm mimo active access netwoRks for QoS-demanding muLtimedia Delivery)
- Mobility projects with North Carolina State, Tokyo Institute of Technology, UCLA

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Selected Topics

- Cross-Layering
- Performance Improvement in Wireless Networks
- Congestion Control
- GRID & Overlay Networks
- Design of Wireless Mesh Networks

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Why Cross-Layering?

- Missing requirements to ensure market convergence

Proper services (Killer applications)

New search technologies, advertising, peer-to-peer networks, personal and community communications

New terminals

At present moment aggressively pushed by Apple, Nokia, Motorola, Intel, and other vendors

High-performance Communications

Cross-Layer Design

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Cross-Layering

<table>
<thead>
<tr>
<th>Technology</th>
<th>Mobility</th>
<th>Data transfer performance</th>
<th>Energy consumption/battery life</th>
<th>Quality of Service</th>
<th>Cross-Layer Design Penetration</th>
</tr>
</thead>
<tbody>
<tr>
<td>2G (GSM)</td>
<td>Fixed</td>
<td>9.6 - 57.6 bit/s</td>
<td>0.52 bit/s/Hz</td>
<td>High</td>
<td>High</td>
</tr>
<tr>
<td>3G (UMTS)</td>
<td>Global roaming</td>
<td>384 Kbps/2MB/s (s)</td>
<td>Up to 2.98 bit/s/Hz</td>
<td>Medium</td>
<td>Medium</td>
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<tr>
<td>3G LTE</td>
<td>Fixed</td>
<td>100 bit/s</td>
<td>0.56 bit/s/Hz</td>
<td>Low</td>
<td>Low</td>
</tr>
<tr>
<td>Fixed WiMAX (802.16-2004)</td>
<td>Global roaming</td>
<td>11 bit/s</td>
<td>0.56 bit/s/Hz</td>
<td>Low</td>
<td>Low</td>
</tr>
<tr>
<td>Mobile WiMAX (802.16e-2005)</td>
<td>Global roaming</td>
<td>2.3 MBs/s (max up to 100 MB/s)</td>
<td>0.56 bit/s/Hz</td>
<td>Low</td>
<td>Low</td>
</tr>
<tr>
<td>802.11b</td>
<td>Fixed</td>
<td>11 bit/s</td>
<td>0.56 bit/s/Hz</td>
<td>Low</td>
<td>Low</td>
</tr>
<tr>
<td>802.11a/g</td>
<td>Fixed</td>
<td>54 Mbit/s</td>
<td>2.7</td>
<td>Low</td>
<td>Low</td>
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<tr>
<td>802.11n</td>
<td>Fixed</td>
<td>250 Mbit/s</td>
<td>7.22</td>
<td>Low</td>
<td>Low</td>
</tr>
<tr>
<td>Bluetooth (2.0)</td>
<td>Fixed</td>
<td>675 Mbit/s</td>
<td>6.55 bit/s/Hz</td>
<td>Low</td>
<td>Low</td>
</tr>
<tr>
<td>UWB</td>
<td>Fixed</td>
<td>675 Mbit/s</td>
<td>6.55 bit/s/Hz</td>
<td>Low</td>
<td>Low</td>
</tr>
</tbody>
</table>

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Cross-Layering

- The key is to understand the implications and possibilities of cross-layering

- Cross-Layer Modeling
  - No analytical model to capture cross-layer interactions

- Protocol Stack Optimization
  - To identify suitable design tools (beyond empirical…

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Performance Improvement in Wireless Networks

- Cellular Network (Main scenario)
  - Content Provider
  - Base Station
  - Wide-Area Network

- Ad-Hoc

- Battlefields

- Network on wheels

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Performance Improvement in Wireless Networks

- **Wireless** vs. **Wired**
  - Limited bandwidth
  - High latency
  - Channel losses
  - High mobility
  - Large bandwidth
  - Low latency
  - Congestion losses
  - Static environment

Poor Communication Protocol Performance

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Performance Improvement in Wireless Networks

- Cross-Layer ARQ

- ARQ agent generate TCP ACKs based on the link layer feedback

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Performance Improvement in Wireless Networks

Cross-Layer ARQ

Cross-Layer ARQ improvements

- Network capacity increase
- Robustness to high error rates
- Reduced round trip delay
- Improved congestion control
- Good fairness & coexistence

Evaluated analytically, by simulations, and on testbed

- Average improvement level tops 100%

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Active Queue Management at bottleneck routers

- A control-theory based optimization
- An Optimal Robust LQR-PID AQM Controller, which:
  - Maintains Queue Size at Routers
  - Improve Congestion
  - Supports QoS
  - Accommodates Load Variation
  - Adjust Change in Network Parameters
Cross-Layer Congestion Control

At every hop
- Compute bandwidth, delay
- Insert computed values into link layer header

At the receiver
- Echo capacity information to sender

At the sender
- Adjust outgoing TCP rate

Adjust rate based on the link capacity

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Cross-Layer Congestion Control

Evaluation outcomes

- Link layer capacity measurements are more efficient
- Cross-Layer Congestion Control is ~30% more productive than other state-of-art solutions
- Proper for upcoming standards (requires a new link layer frame)

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GRID & Overlay Networks

- To analyze the offered load by grid applications onto the networking infrastructure
- To enable grid overlays to be adaptive to availability and fluctuations of host and network resources
Design of Wireless Mesh Networks

- A Wireless Mesh Network testbed is currently running at DISI premises (802.11a/5GHz)

- The testbed is built using Linux-based programmable Aps

- An Open Platform for developing and validating

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Design of Wireless Mesh Networks
Design of Wireless Mesh Networks

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Research Outputs

- **Book Chapters and Journals**
  - Elsevier Computer Networks Journal (COMNET)
  - ACM / Springer Wireless Networks (WINET)
  - International Journal of Computer Research
  - Ad Hoc Networks Journal
  - Journal of Interconnection Networks (JOIN)

- **Conferences**

- **Patents**

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International Contacts

- North Carolina State Univ. (Prof. M. Devetsikiotis)
- State Univ. of Campinas (Prof. N. Fonseca)
- Tokyo University of Technology (Prof. Tsuboi)
- Nokia Siemens Networks (Ing. S. Redana)
- UCLA (Prof. M. Gerla)

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Any questions?

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