Faculty

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Network Coding

• **Basic Idea**
  – Allow intermediate nodes to combine packets
  – Receivers must decode to obtain source packets

• **Benefits**
  – Can improve throughput
  – Can make distributed scheduling easier

• **Potential Applications**
  – Wireless multihop networks
  – Peer-to-peer networks
Making Network Coding Practical:

• **Cross-layer Optimization of Coded Wireless Networks**
  – Make network coding work best with TCP or video traffic and in the presence of loss [see poster]

• **Network Coding and Topology Inference**
  – Use network coding to reverse engineer properties of the network [see poster]

• **Network Coding and Security**
  – Network coding is vulnerable to byzantine pollution attacks
  – Novel security mechanisms are needed

• **Network Coding and Interference Alignment**

• **Implementation on Smartphones**
  – At the MAC (for wireless) or the application (for p2p) layers [see poster]
Developed reference OFDM and OFDMA systems to evaluate performance of key wireless communications algorithms

- Spectral efficiency: Up to 4x4 MIMO
- Reconfigurability:
  - Meters: providing signals to be used in the decision engine (cognitive and software defined radio research)
  - Capability to experiment with multiple algorithms: Modular design with de-centralized scheduling
    - Sphere decoding architectures
    - Channel estimation techniques
    - Low Power VLSI architectures
    - Reconfigurable architectures, e.g., FEC
    - Block boundary detection
    - Synchronization techniques etc.
• WARP: Wireless Open Access Research Platform from Rice University
  – Programmable carrier frequency (2.4, 4.9, 5 GHz)
  – Virtex-II pro FPGA (PHY)
  – Embedded microcontroller (MAC)
  – Support up to 40MHz of bandwidth
• Daughter Card supports Virtex-5 FPGA for expandability
More and more of human online activity is carried on or influenced by OSNs. E.g., email communication; voice and video communication (skype); photos and videos (flickr, youtube); news; recommendation systems…

<table>
<thead>
<tr>
<th>Size</th>
<th>Rank</th>
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<tbody>
<tr>
<td>500 million</td>
<td>2</td>
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<tr>
<td>200 million</td>
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<td>130 million</td>
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</tr>
<tr>
<td>75 million</td>
<td>10</td>
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<tr>
<td>75 million</td>
<td>29</td>
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</tbody>
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(in November 2010)

> 1 billion users
> 15% of world’s population
> 50% of world’s Internet users

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• **Sampling**: Crawl OSN graphs and obtain representative samples
  - Random Walks on Facebook
  - Exploration techniques (e.g. Breadth-First-Search)
  - Multigraph Sampling of Last FM
  - Stratified Sampling of Facebook

• **Content distribution**
  - Content becomes popular over OSNs (overlay) but eventually is carried over the communication infrastructure (underlay)
  - 3G operators can use mechanisms (pre-fetching, caching, ad-hoc connectivity) to off-load their network
  - [see Poster on “OSNs meet Smartphones”]
Use measurements of network traffic and machine learning techniques on appropriately selected features to detect/predict malicious activity.

**Example of information logged per packet**

<table>
<thead>
<tr>
<th>Time</th>
<th>Victim network</th>
<th>Src IP</th>
<th>Dst IP</th>
<th>Src Port</th>
<th>Dst Port</th>
<th>Protocol</th>
<th>Flags</th>
</tr>
</thead>
</table>

**Graph**

- **Traffic volume**
- **Source IP**
- **Time (day)**
• **Stop Malicious IP Traffic (e.g. DDoS attacks)**
  – At the edge of the network:
    • Predict future malicious traffic (using techniques from recommendation systems) based on past measurements at various places in the network
    • Block malicious traffic (using prefix-based filters in TCAM)

• **Phishing**
  – Classify phishing sites using machine-learning techniques on lexical features only (the URL name) [INFOCOM’11]
    – [see poster on PhishDef]

• **Click-Fraud Detection**
• **Universal Software Radio Peripheral (USRP)**
  - Enables rapid prototyping of SDRs

• **Hardware**
  - Motherboard implements FPGA baseband
  - Connects to GPP using USB/Gb-ETH
  - Daughterboards implement RF front-end

• **Is Programmed Using GNU Radio**
  - Implemented in Python/C++ under Linux

• **Full IP Stack**
  - Is implemented in Linux
• MIMO OFDM PHY
  – MRC, STBC, STTC

• Load Adaptive Hybrid MAC
  – Hybrid CSMA-TDMA Behavior
  – Cooperative LA-MAC

• PHY-MAC Interference Mitigation
  – Simultaneously Transmit on Same Frequency
  – Use MIMO to Extract Collided Signals
• Cross-Layer Routing
  – TCP BIC/CUBIC
  – VCP, MPCP

• Cross-Layer Transport
  – LA-MAC Assisted MDR
  – IPSec Encrypted

• Applications
  – File and Image Delivery
  – Stored/Live Audio Delivery
  – Stored/Live Video Delivery
• SOA-Based Monitoring
  – Heartbeat Statistics
    thru GPS-Based Laptops

• Connectivity Graphs
  (PHY/MAC/NETOWORK)
  – LA-MAC reports SINR, SER,
    and FER statistics
  – MDR HELLO messages reported
to the monitoring console
  – Collect Performance Data
    (Link Quality, Loss, Delay)
  – SNMP MIBs

• Cognitive Policy-Based Network Mgmt (PBNM)
• **Apps thru NMS Monitoring**
  – Healing Partitioned MANETs
  – Reach Back
  – Range Extension

• **Connectivity Augmentation**

  A Small No of ANs
  – USRP2, UAVs
  – AN Placement Algorithms
    Small World Phenomenon, Percolation, and Graph Theory
  – Formation of ANs Using Cooperative Comm Techniques
Small Form Factor Sensors

New Horizon

- **Environments of Interest**
  - Position Location Monitoring
  - Battlefield Health Monitoring
  - Civilian medical Monitoring

- **Signals of Interest**
  - GPS, Audio, Video, Vital Signs

- **Technology Platform**
  - Hardware: Gumstix (Ocero Fire) and Motes (MICAz, IRIS)
  - Software: IP Stack under Development at UCI