Green Wireless Cognition: Future Efficient Spectrum Sharing

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Bell's Law*: Every decade sees a change in the class of computing devices

- 1990s saw the emergence of the laptop;
- 2000−2010 saw the mobile phones
- Next decade, desktops will disappear. End−user computers will be almost entirely laptops and tablets plugged into large displays and keyboards when needed.
- Data and applications will live in the cloud. Users can access them anytime, anywhere.
- Ubiquitous high−speed wireless connectivity is a must.
- Dense, small−range wireless access points will become more important than today.
- Spectrum is limited, neighboring APs will likely have to operate on the same spectrum.
- Interference between neighboring APs will become the dominating factor.
- Small cells connectivity and load will fluctuate rapidly, both in space and time.

Current wireless design does not accommodate such demands!

We aim to reengineer wireless systems to cope with future networking demands in the following ongoing projects:

- Wireless Buffering in Multi-hop Networks
- Wireless Video Multicasting over WiMax
- Wireless Green Spectrum
- Wireless Sensor in Underwater Networks

* Bell's Law of Computer Classes formulated by Gordon Bell in 1972, describes how types of computing systems (referred to as computer classes) form, evolve and may eventually die out.
Buffer Sizing in Wireless Multihop Networks

The invention provides a buffer sizing strategy for optimizing bursty as well as real-time traffic in multi-hop wireless networks. It sizes the collective neighborhood buffer of a set of wireless nodes that constitute the network bottleneck. The buffer is sized just large-enough to saturate the capacity of the bottleneck spectral resource without increasing the packet delay. The scheme removes the unnecessary extra hardware and improves the network performance.

The project aims to transmit scalable video by Super Position Coding (SPC) to demonstrate different video quality will be received under different wireless channel quality. If the channel quality is good, enhanced quality video can be received. If the receiver signal is weak, at least the base quality video can be played. The generated video is extracted into 2 layers, Base and Enhancement by BitStreamExtractor developed by the networking group at KAUST. The testbed consists of two WiMax emulators shown in the figure. The emulators are connected by RF cables through a variable attenuator from up converter on transmitter to down converter on receiver.

Collaborative Inspection & Repair by Autonomous Underwater Vehicles

The project aims to develop an unmanned fully autonomous underwater vehicles (UWV) system and to demonstrate its operation using collaborative and distributed control. We overcome the challenges of underwater communications by an integration of sensor and multi-hop networks. Human intervention is reduced. The vehicles are wirelessly coordinated to reliably transmit the control data in flow fashion. The vehicles are intended to work in relative independence from the mother vessel. In our solution model, we introduce a special class of sensor and mesh networks, called Flow Sensor-Mesh Networks (FSMN).

G²: Green coGnition Wireless Radio

This project aims to develop a framework for facilitating green spectrum in cognitive radio networks. G² is a framework to manage cognitive radio functionality and provide optimal parameters for wireless channel. It is based on cross-layer design to collect sensory information from all layers along with application QoS requirements. G² consists of three layers: Communication Layer, Decision making Layer, and Policy Layer.

- Collaborative project with TAMU in Qatar, Sup’Com, INPT, KFUPM. Submitted to KAUST OCRF, 2012.
System Prototypes and Software Packages

- **System Prototypes**
  - 10 IEEE 802.11/b/g/n Mesh nodes for neighborhood buffer sizing.
  - Two WiMax emulators for video coded multicasting over WiMax channels.
  - 20 sensor motes for smart wireless guided system.
  - 6 USRP-2 cognitive radio for green cognitive.

- **Software Packages**
  - Wireless extension to the well known ethtool for buffer sizing measurements in Linux.
  - Implementing different channel widths in 802.11 nodes for NS-3.
  - Enabling Timestamp-based MAC functionality in 802.11 nodes for NS-3.
  - Measure queue utilization in 802.11 nodes for NS-3.

Network Simulator (NS-3) is global networking simulation tool.
KAUST NetLab Research Team

http://www.netlab.kaust.edu.sa
Selected Publications & Patents


**QICST Shine** is the most known conference on quality of service in networks

**MobiHoc** is one of the ACM Sigmobile conference series. This is one of the toughest conferences in wireless networks
Continuing Research Agenda

Initial Phase

- Delay Tolerant Networks
  - Buffer Management
  - Routing
  - Congestion Control
- Ethernet Passive Optical Networks
  - Quality of Service
  - Wavelength assignment
  - Green Optical Communication

Future Phase

- Wireless Full Duplex
  - Interference Management
  - Hardware prototyping
  - Buffering
- Wireless Actuator Networks
  - Monitoring
  - Reliability
Reengineer Wireless Systems: Summary

- Wireless Buffering in Multi-hop Networks
  - Buffer Sizing in IEEE 802.11b/g/n
- Wireless Video Multicasting over WiMax
  - Video Multicasting
  - Multiuser Diversity
- Wireless Green Spectrum
- Wireless Sensor in Underwater and Actuator Networks
  - Reliability
  - Monitoring
  - Localization
- Delay Tolerant Networks
  - Buffer Management
  - Routing
  - Congestion Control