Providing performance guarantees in wireless networks

P. R. Kumar
Dept. of Electrical and Computer Engineering
Texas A&M University

Email: prk.tamu@gmail.com
Web: http://cesg.tamu.edu/faculty/p-r-kumar/

Visions for Future Communications Summit
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Lisbon Portugal
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“In the services track we will discuss new communications services, their requirements and their impact on a changing society, including aspects such as cloudification and protection against cyber crime and cyber war.”

In-Vehicle Networks

Wire harnesses are:

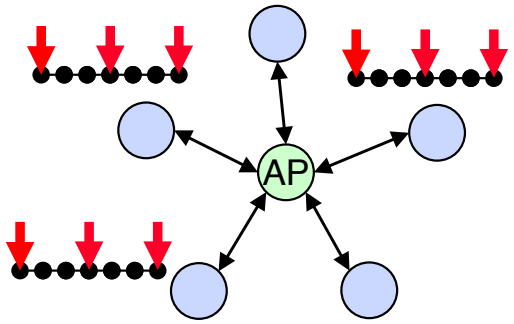
Costly (> $1000)

Complex (> 4000 parts)

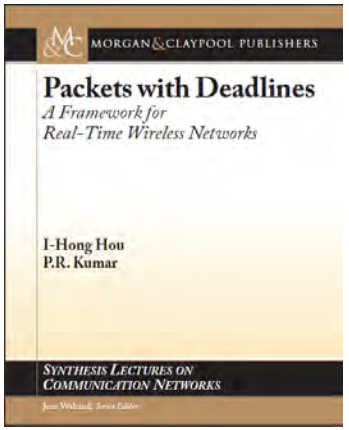
Heavy (> 40 kg)

Warranty issues (> 65 IPTV)

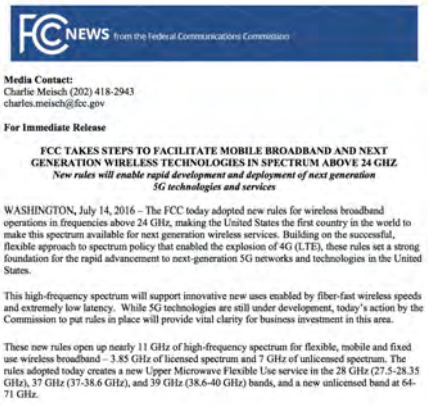
- Replace wires by a wireless access point



- Packets have deadlines
- Flows have throughput requirements
- Channels are unreliable



FCC Action on July 14, 2016



FCC NEWS from the Federal Communications Commission

Media Contact:
Charlie Meisch (202) 418-2943
charles.meisch@fcc.gov

For Immediate Release

FCC TAKES STEPS TO FACILITATE MOBILE BROADBAND AND NEXT GENERATION WIRELESS TECHNOLOGIES IN SPECTRUM ABOVE 24 GHZ
New rules will enable rapid development and deployment of next generation 5G technologies and services

WASHINGTON, July 14, 2016 – The FCC today adopted new rules for wireless broadband operations in frequencies above 24 GHz, making the United States the first country in the world to make this spectrum available for next generation wireless services. Building on the successful, flexible approach to spectrum policy that enabled the explosion of 4G (LTE), these rules set a strong foundation for the rapid advancement to next-generation 5G networks and technologies in the United States.

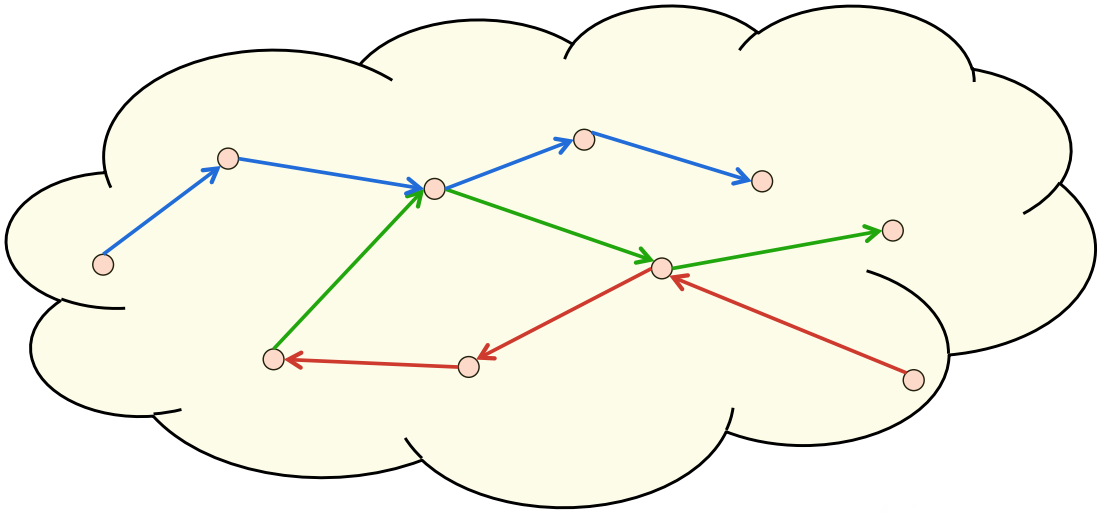
This high-frequency spectrum will support innovative new uses enabled by fiber-fast wireless speeds and extremely low latency. While 5G technologies are still under development, today's action by the Commission to put rules in place will provide vital clarity for business investment in this area.

These new rules open up nearly 11 GHz of high-frequency spectrum for flexible, mobile and fixed use wireless broadband – 3.85 GHz of licensed spectrum and 7 GHz of unlicensed spectrum. The rules adopted today creates a new Upper Microwave Flexible Use service in the 28 GHz (27.5-28.35 GHz), 37 GHz (37-38.6 GHz), and 39 GHz (38.6-40 GHz) bands, and a new unlicensed band at 64-71 GHz.

- 10.85 GHz spectrum in mm band released
  - 3.85 GHz licensed
  - 7 GHz unlicensed
- 18GHz more proposed for later release
- MM Wave Challenges
  - Directional transmission
  - Absorption

A new wireless information age?

Multi-hop networks with end-to-end guarantees?



Throughput Optimal Decentralized Scheduling of Multi-Hop Networks with End-to-End Deadline Constraints: Unreliable Links

Rahul Singh *Member, IEEE,* and P. R. Kumar *Fellow, IEEE,*

***Abstract*—We consider multi-hop networks serving multiple flows in which packets not delivered to their destination nodes by their deadlines are dropped from the network. The throughput of packets that are delivered within their end-to-end deadlines is called the timely-throughput. We address the design of policies for routing and scheduling packets that optimize any specified weighted average of the timely-throughputs of several flows, under nodal power constraints.**

We provide a new approach which allows tractable computation of an optimal decentralized scheduling policy that attains any desired maximal timely-throughput vector under average-power constraints on the nodes. All decisions regarding a packet's transmission scheduling, transmit power [2]. However, the links are subject to absorption in this band. Thus multiple hops are needed to traver longer distances. This motivates the problem studied in this paper: How to achieve the maximal throughput of packets meeting hard end-to-end delay bounds over multi-hop wireless networks of unreliable links?

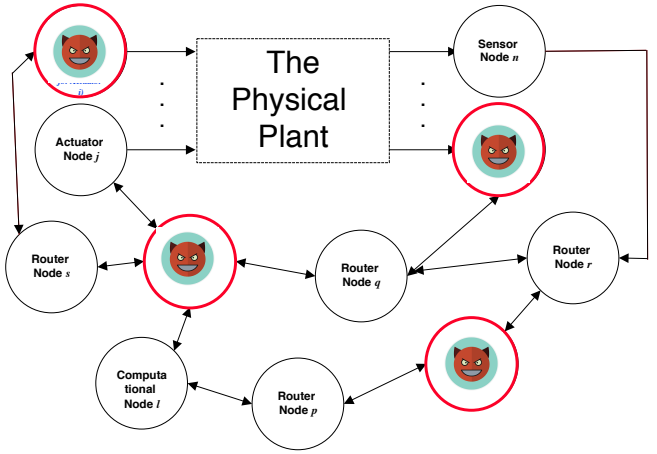
The past quarter century has seen the pioneering work of Tassiulas and Ephremides [3], Lin and Shroff [4], Lin, Shroff and Srikant [5], Eryilmaz and Srikant [6], and Neely, Modiano and Rohrs [7] on Max-Weight and back-pressure based scheduling policies for communication

Security of Cyberphysical systems

- Overall system has
  - Physical plant
  - Actuators
  - Sensors
  - Routers
  - Computational nodes
  - Network

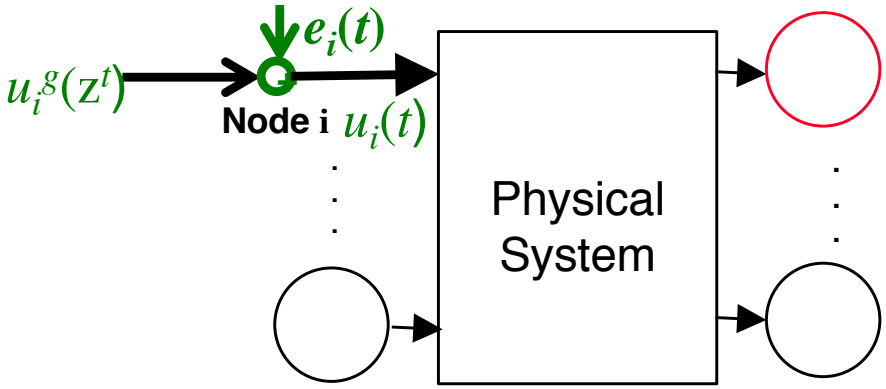
- But some of the routers, computation nodes, sensors, actuators may be compromised

- How do we secure the overall cyberphysical system?



- Semantic layer defense
- Dynamic watermarking

Random noise $e_i(t)$ is privately added to the signal



CONTRIBUTED PAPER

Dynamic Watermarking: Active Defense of Networked Cyber–Physical Systems

This paper investigates the problem of secure control of networked cyber–physical systems.

By Bharadwaj Satchidanandan and P. R. Kumar, *Fellow IEEE*

Thank you