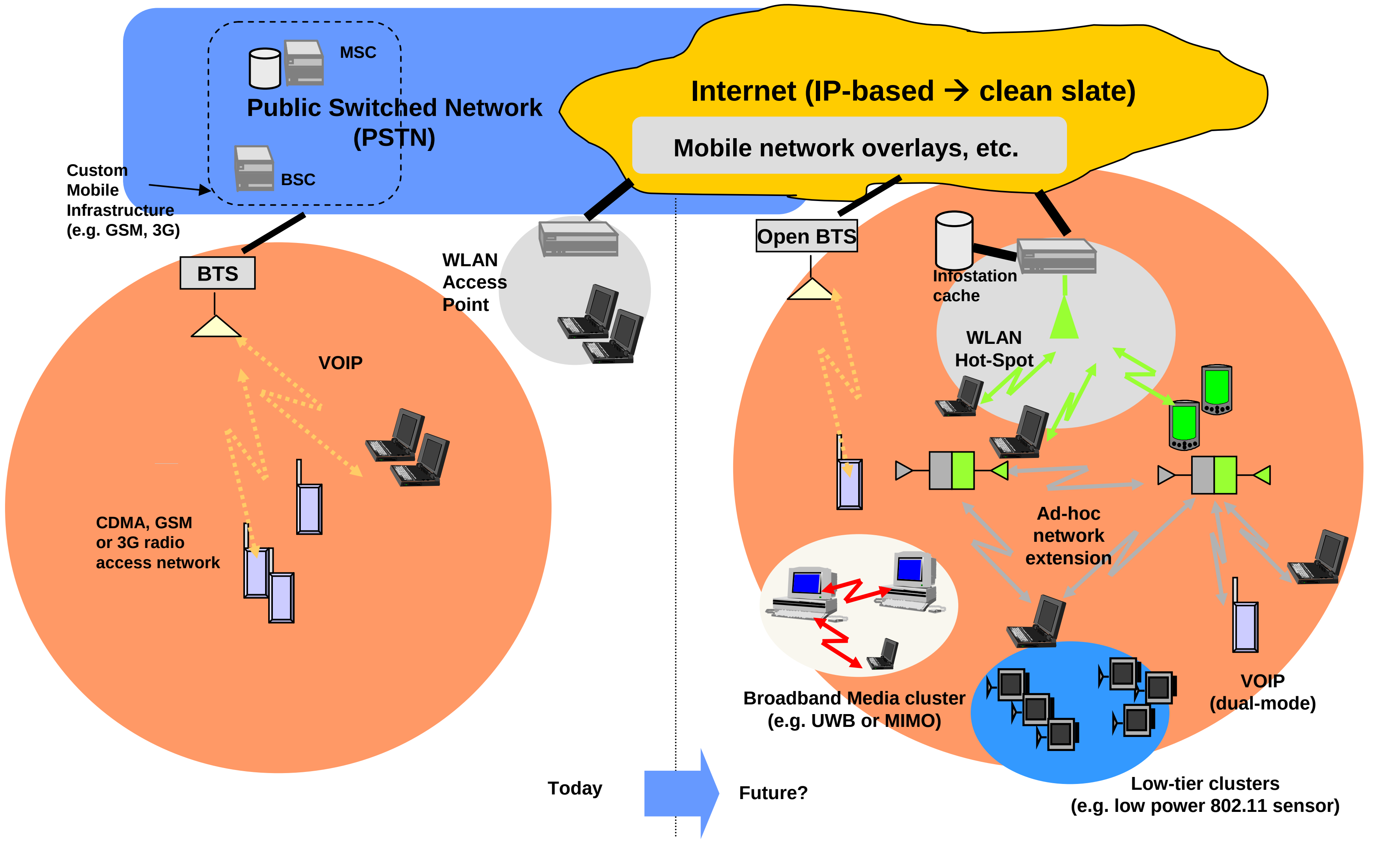
# Overview of Adaptive Networking Research at WINLAB

*Wade Trappe*

WIRELESS INFORMATION NETWORK LABORATORY

# The Motivating Vision




WINLAB
WIRELESS INFORMATION NETWORK LABORATORY

# Overview: Today and Adaptive Networks

| | |
|---|---|
| 1 Faculty Area Overviews | • WINLAB research overviews in topics related to adaptive wireless networks: networking, physical layer, hardware platforms, and vehicular networks. |
| 2 Keynote Speech and Demonstrations | • Visions of where wireless research is heading, and where it should **not** head!<br>• Walk through of WINLAB systems research and platforms |
| 3 Physical Layer | • What opportunities are there for cooperation at the lower layers for wireless communication? |
| 4 Spectrum Awareness | • How do we build the knowledge needed to take advantage of spectrum opportunities? |
| 5 Adaptive Protocols | • How can we adapt the network to cope with the challenges of distributing data and maintaining desirable levels of connectivity? |

# WINLAB Adaptive Networks

## Requirements

•Applications need rapid response to dynamic conditions
•Networks should support multiple services with different QoS objectives
•Services should be secure and robust

## Approaches

•Sharing of information across layers
•Sharing of measurements beyond local neighborhoods
•Tight and robust coupling between layers of the stack

## Control Plane Architecture

**Benefits:**

- Decouples control and data plane
- More assured establishment of network services
- Easier to distribute critical network information
- Easier to secure critical network functions

## WINLAB Initiatives

**Global Control Plane (GCP):**

- Cognitive radio networks

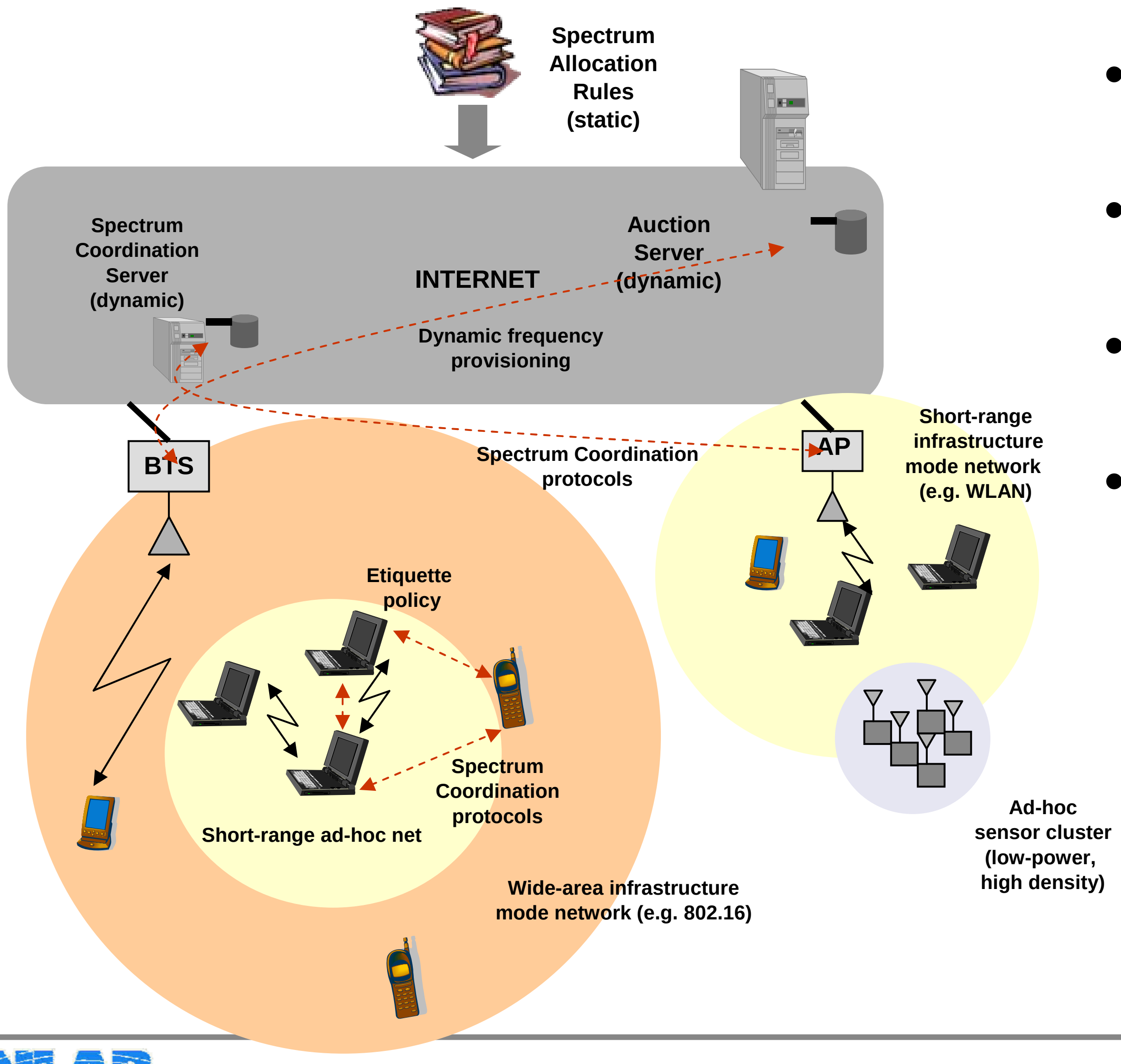
**Cross Layer Ad Hoc Nets (CLAN):**

- D-LSMA
- IRMA
- WARP-5

**Secure MANETs (CARMEN)**

- Four Ounces
- SEAR

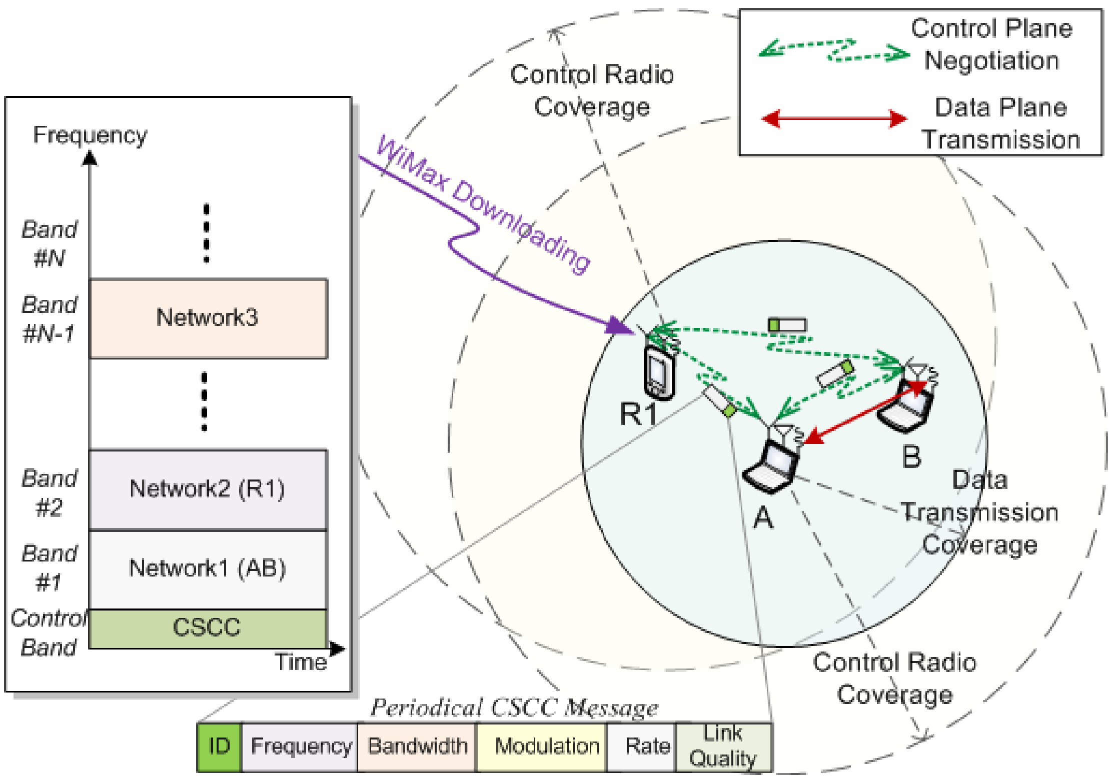
# Dynamic Spectrum: Problem Scope




- Dense deployment of wireless devices, both wide-area and short-range
- Proliferation of multiple radio technologies, e.g. 802.11a,b,g, UWB, 802.16, 4G, etc.
- How should spectrum allocation rules evolve to achieve high efficiency?
- Available options include:
  - **Agile radios (interference avoidance)**
  - **Dynamic centralized allocation methods**
  - **Distributed spectrum coordination (etiquette)**
  - **Collaborative ad-hoc networks**

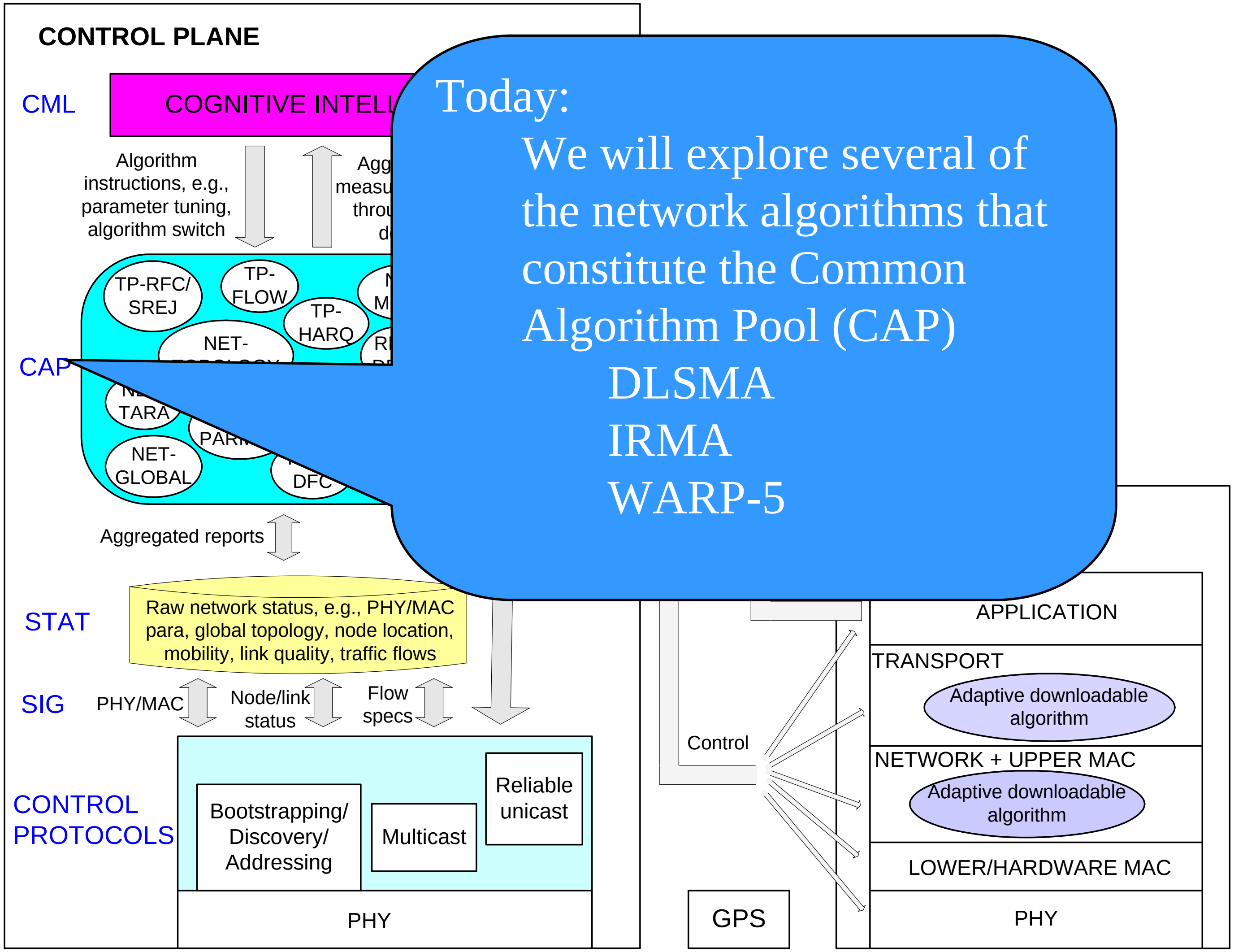
# *Dynamic Spectrum: Common Spectrum Coordination Channel (CSCC)*

- CSCC enables mutual observation between heterogeneous nodes to explicitly coordinate spectrum usage




- Exchange of CSCC messages by an extra narrow-band (low bit-rate) radio
- Periodically broadcast self-states to others
- Coordinate spectrum usage

# Cross-Layer Ad Hoc Networks: CLAN Architecture



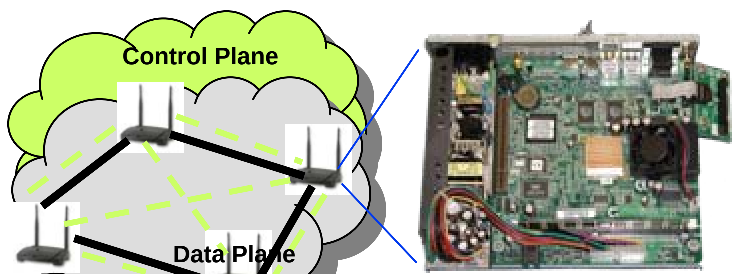

Today:

We will explore several of the network algorithms that constitute the Common Algorithm Pool (CAP)

- DLSMA
- IRMA
- WARP-5

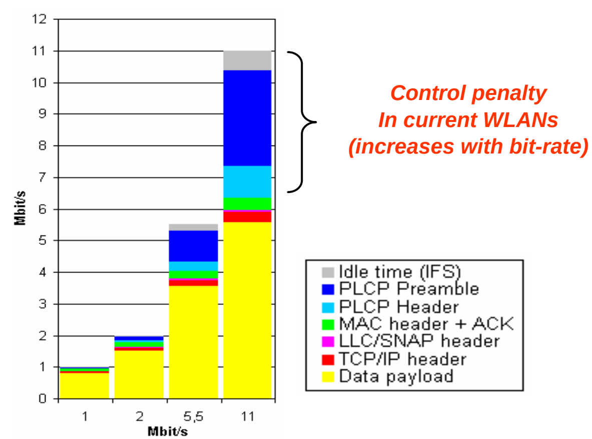
# *Ad Hoc Networks:* Dual Radio Nodes with Global Control Plane (GCP)

- **Separate control and data planes: reduces control overhead and enables contention-free global MAC/routing algorithms**
- **Can use a single low rate channel (e.g. 1 mbps 802.11b) for control**
- **Ad hoc network with global control currently being prototyped on ORBIT**

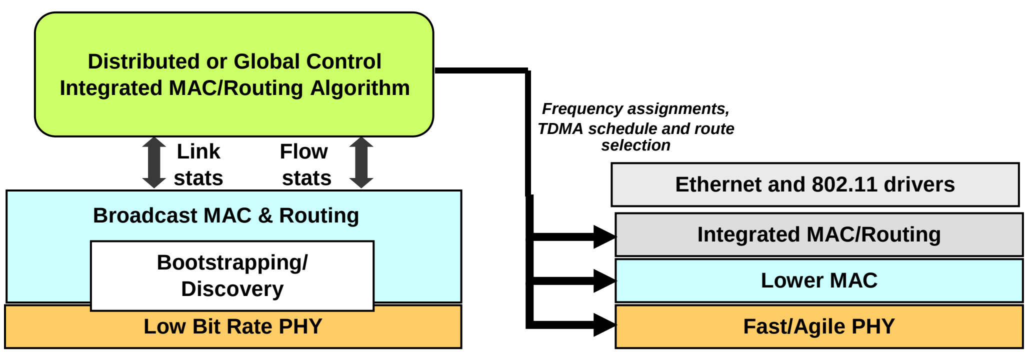



ORBIT dual-radio node

*Example of WLAN throughput breakdown*



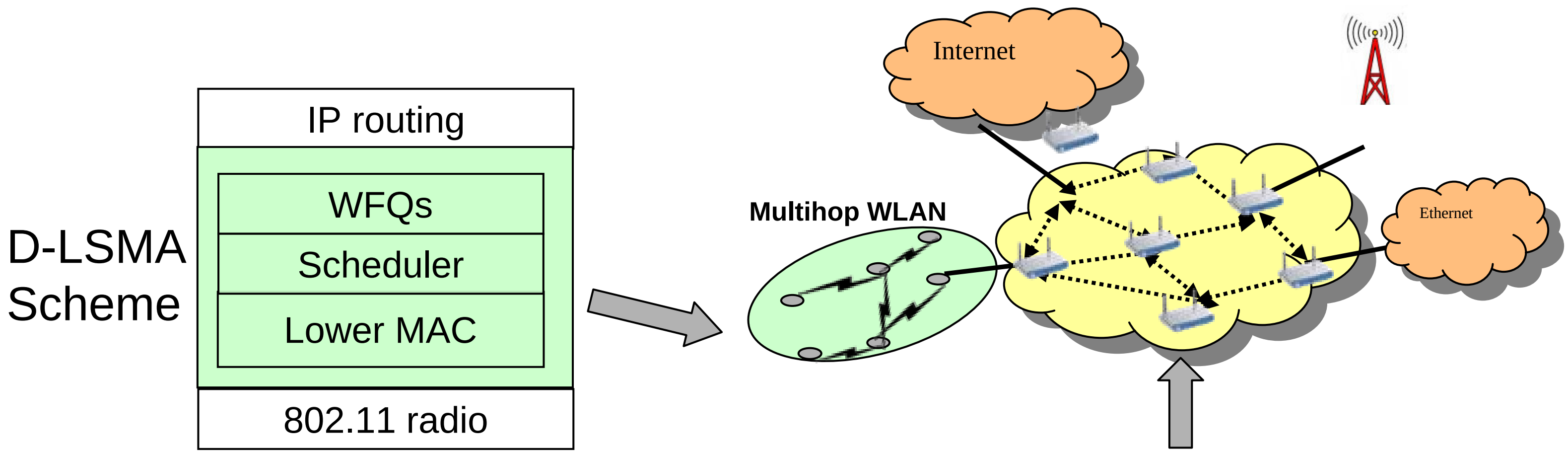

http://www.uninett.no/wlan/throughput.html



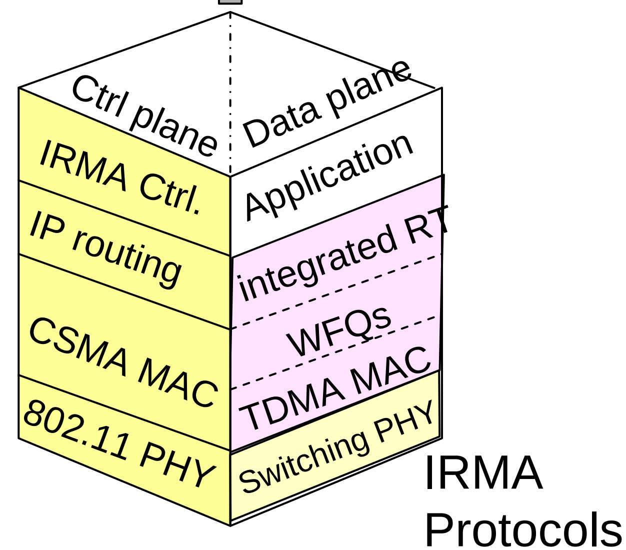

Control Plane

Data Plane

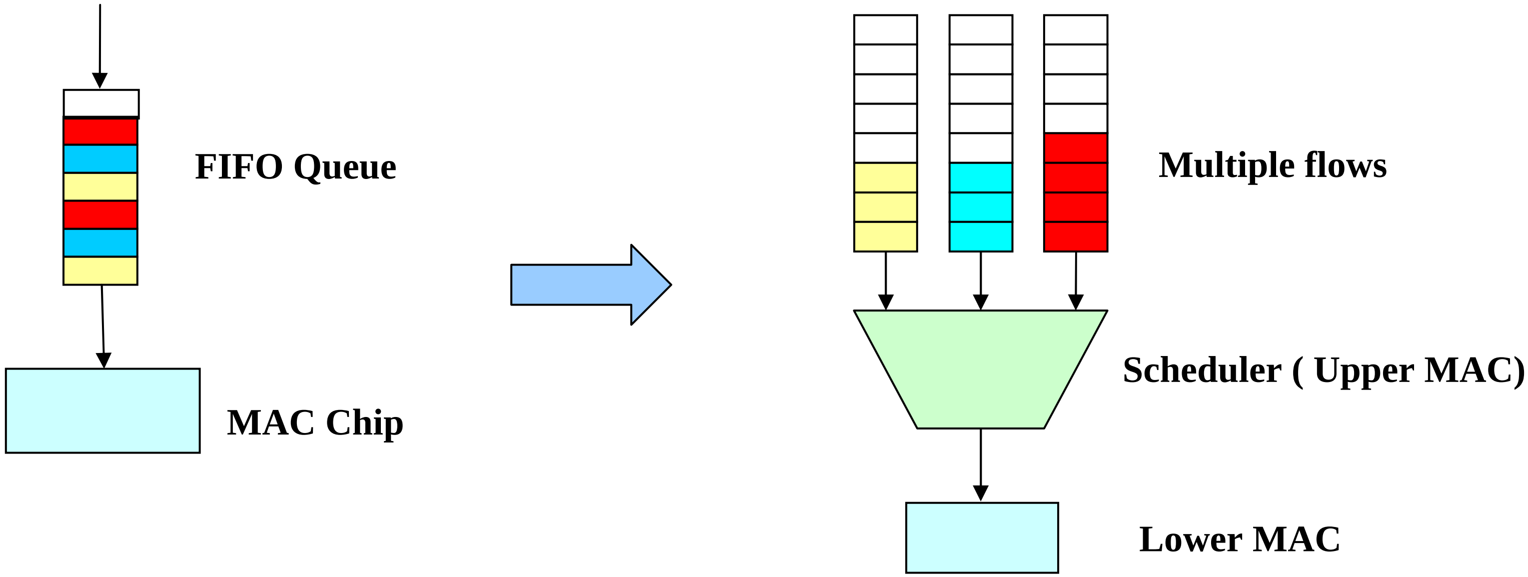
# Framework of WINLAB Solutions




- Eliminate interference
  - Interference-free link scheduling
- Ensure QoS
  - Use flow-based multiple queues to differentiate
  - Collect traffic flow load information
  - Bandwidth allocation/reservation
- Robust control
  - A separate control plane on control channel



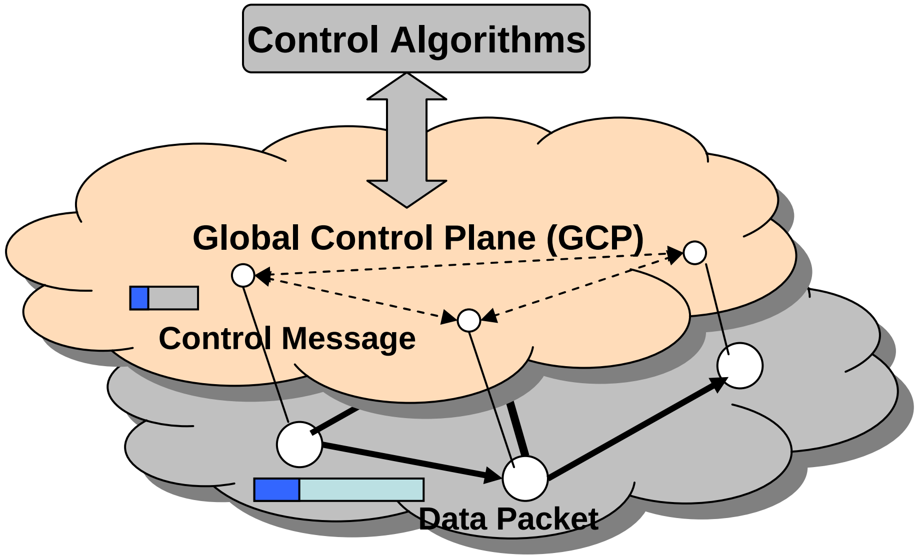
# D-LSMA: New MAC Architecture

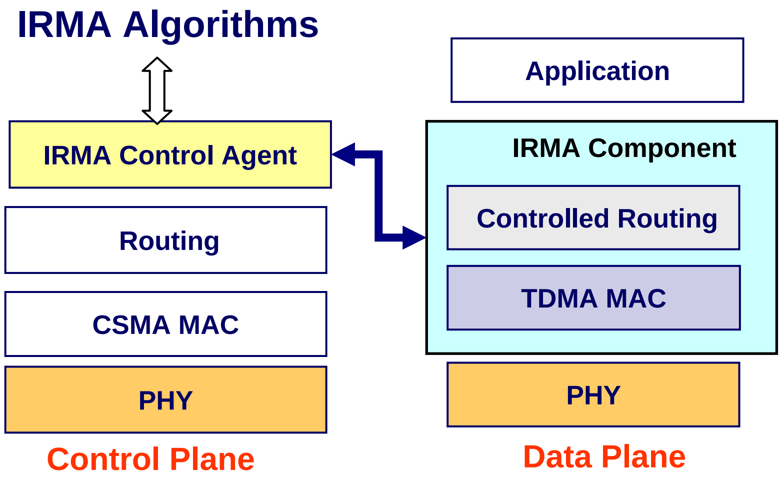



- **Old**
  - **Same MAC scheme for all kinds of traffic in a single FIFO queue**
- **New**
  - **Classify packets based on different destination or traffic demands.**
  - **Scheduler: Choose a "good" schedule for buffered packets or flows and make reservation decisions.**
- **Requires:**
  - **Nodes have to discover the opportunities for link scheduling.**
  - **Build a schedule table by processing overheard RTS/CTS.**
  - **Reduce Contention**
    - *Try to reserve multiple packets in one RTS/CTS handshake*

# IRMA System Model

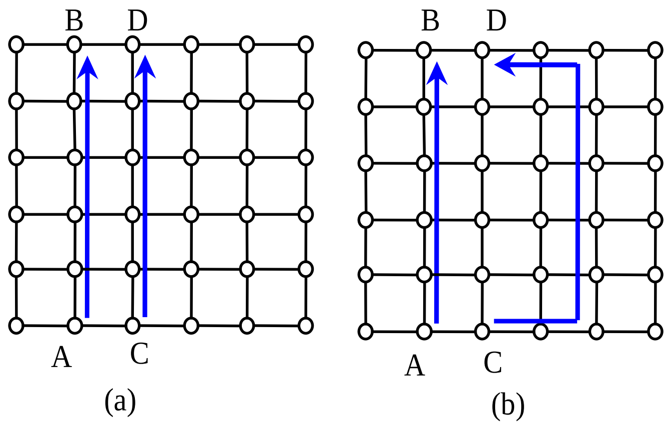
- Global control plane and data plane
  - All control signaling on a separate plane
  - Each node uses another radio interface over a dedicated control channel
  - Parameters of IRMA component in data plane is determined by control algorithms
- IRMA approach reduces signaling overhead as well as improves throughput performance



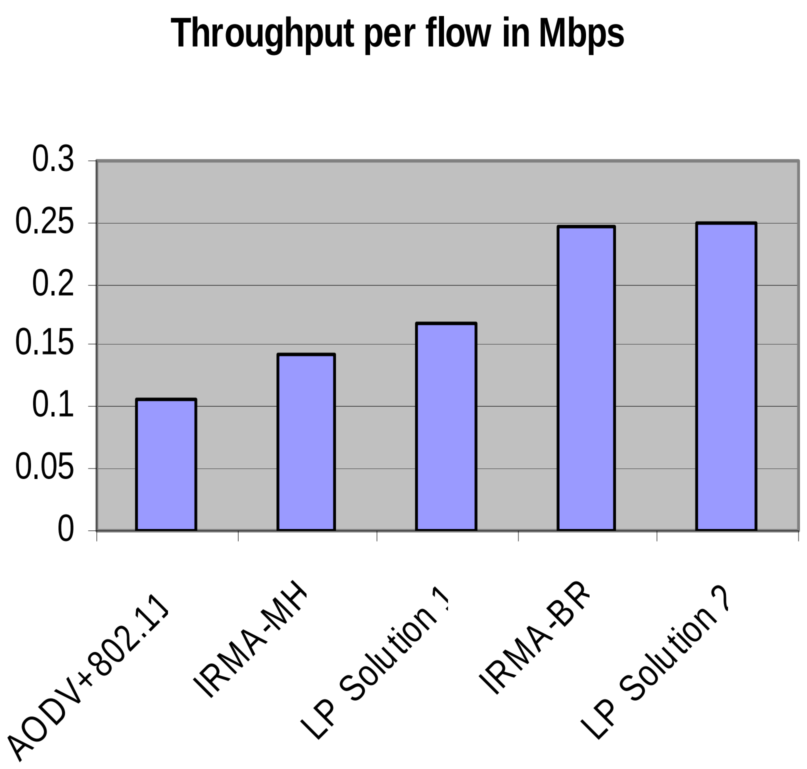




Protocol stacks in IRMA system

# IRMA-MH vs. IRMA-BR




**Different routes used by (a) IRMA-MH and (b) IRMA-BR in a 6x6 grid for two vertical flows**




- IRMA-BR algorithm chooses a detour path to route around possible congested areas by using available bandwidth measurement as metric

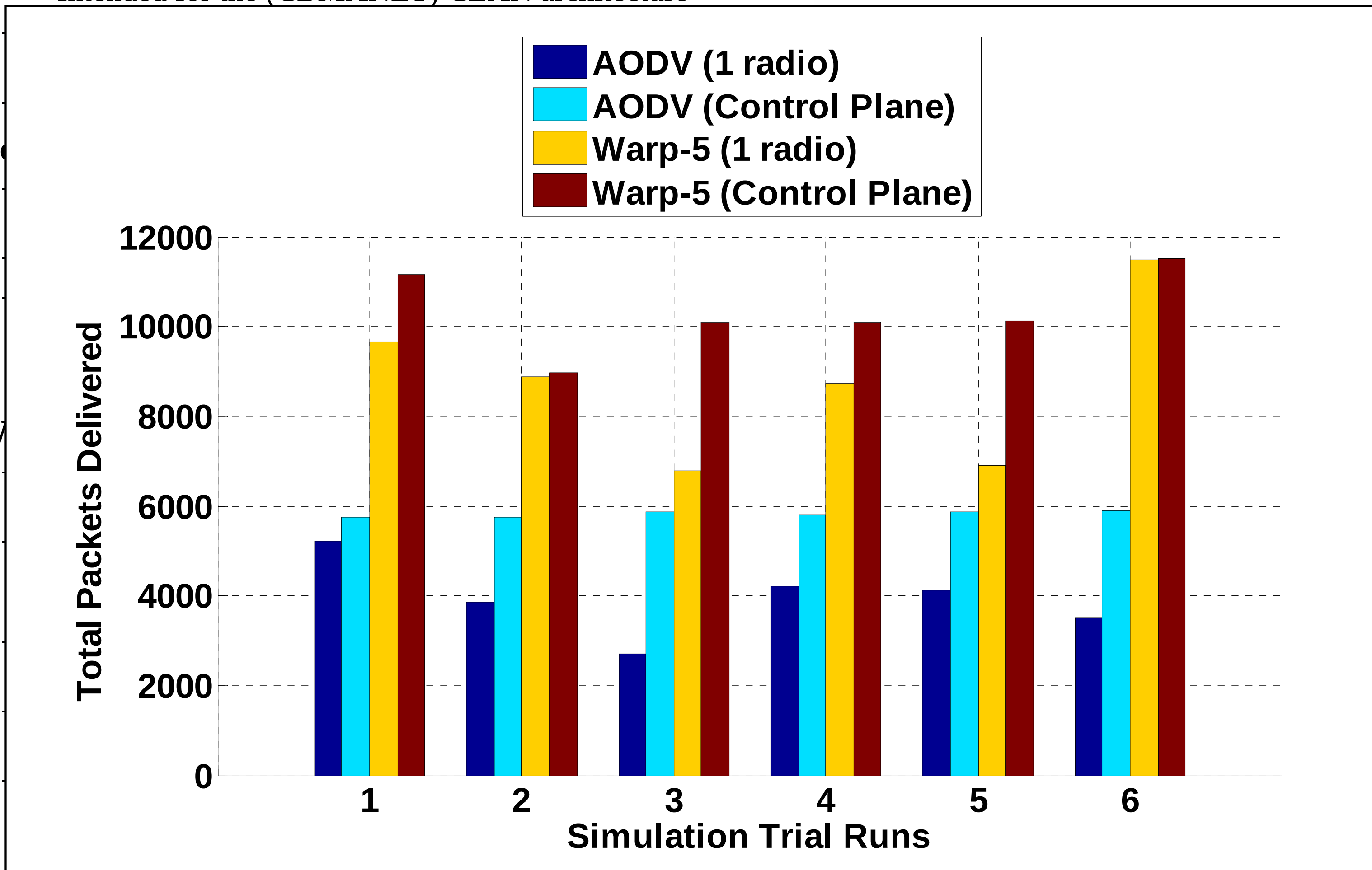
# *Warp-5: Wireless Adaptive Routing Protocol*

- **Overview:**
  - Intended for the (CBMANET) CLAN architecture

**AODV-based Routing: Overload**

- **D**
- **W**

**ancing**




Nodes 1, 2 and 3 all find the fastest route.