
# Wireless Virtualization

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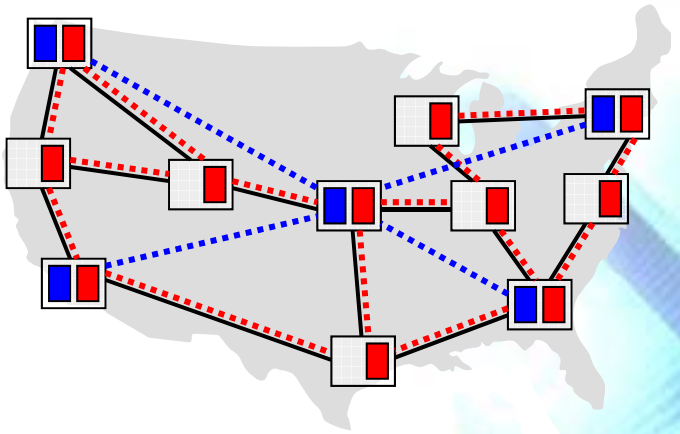
**Heejin Lee**
**Prof. Chong-kwon Kim**

# Contents

- Introduction to wireless virtualization
- ORBIT testbed virtualization efforts
  - Frequency division Multiplexing
  - Time division Multiplexing : VAP
  - Space division Multiplexing : TPC
- OpenFlow Wireless: OpenRoads
  - OpenFlow enabled APs, BSs, Switches

# Virtualization in Wireless Networks



- Wired Networks
  - Node virtualization
    - Xen, VMWare, etc…
  - Link virtualization
    - Concrete foundation from overlay network
- Wireless Networks
  - Node virtualization
    - Same as wired
  - Link virtualization
    - Trouble stemming from the nature of wireless communication, broadcast
- Consequences
  - Strategy of slicing the wireless medium
  - Analogous to multiple access way in wireless communication

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# ORBIT testbed virtualization
## :FDM, TDM, SDM

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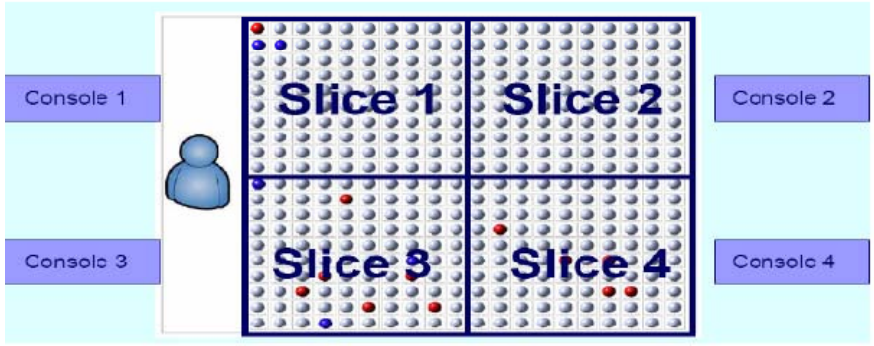
# GENI Spiral 2

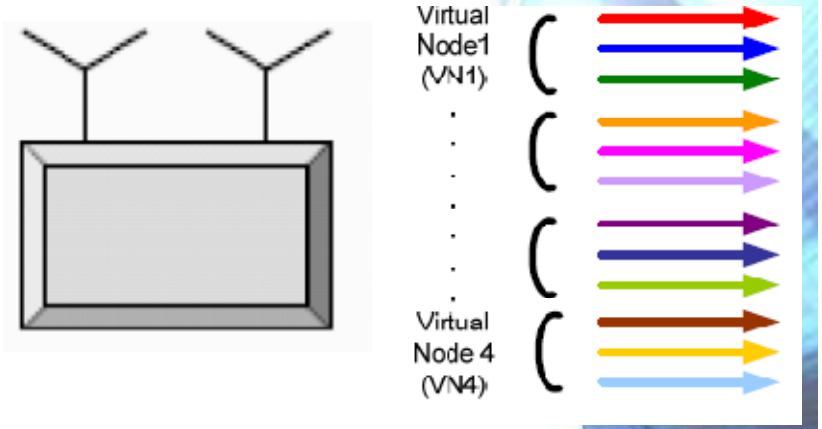
| | PlanetLab Cluster (B) | ProtoGENI Cluster (C) | ORCA Cluster (D) | ORBIT Cluster (E) | Cluster TBD |
|---|---|---|---|---|---|
| *Cluster Integration Info* | Cluster wiki | Cluster wiki | Cluster integ<br>Connectivity plan | Cluster integ | |
| *Control Framework Design and Prototyping* | PlanetLab | ProtoGENI<br>DigitalObjectRegistry<br>PGAugmentation | ORCA/BEN<br>ORCA Augmentation | ORBIT | |
| *Network Aggregate Design and Prototyping* | Mid-Atlantic Crossroads<br>GpENI | BGPMux<br>CRON<br>PrimoGENI | ORCA/BEN<br>iGENI<br>LEARN | | |
| *Programmable Network Node Design and Prototyping* | EnterpriseGeni<br>Internet Scale Overlay Hosting | CMULab<br>ProgrammableEdgeNode | | | |
| *Compute Aggregate Design and Prototyping* | GENICloud | MillionNodeGENI | Data Intensive Cloud Control | | |
| *Wireless Aggregate Design and Prototyping* | | CMULab | DOME<br>ViSE<br>KanseiSensorNet<br>OKGems | ORBIT<br>WiMAX D&P<br>COGRADIO | |
| *Instrumentation & Measurement Design and Prototyping* | VMI-FED | InstrumentationTools<br>MeasurementSystem<br>OnTimeMeasure<br>LAMP<br>ScalableMonitoring | ERM<br>LEARN<br>IMF | | |
| *Experiment Workflow Tools Design and Prototyping* | GushProto<br>ProvisioningService (Raven)<br>netKarma<br>SCAFFOLD | PGTools | | | |
| *Security Design and Prototyping* | SecureUpdates | ExptsSecurityAnalysis<br>ABAC | | | HiveMind |
| *Early Experiments* | | OpportunisticWirelessNets<br>DavisSocialLinks(DSL) | | | |

# Wireless virtualization

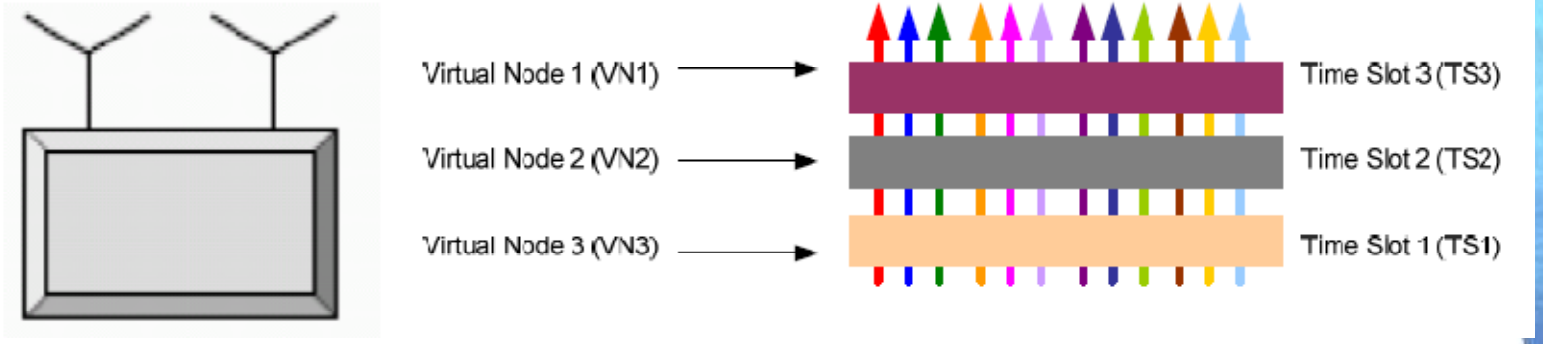
SDMA




FDMA

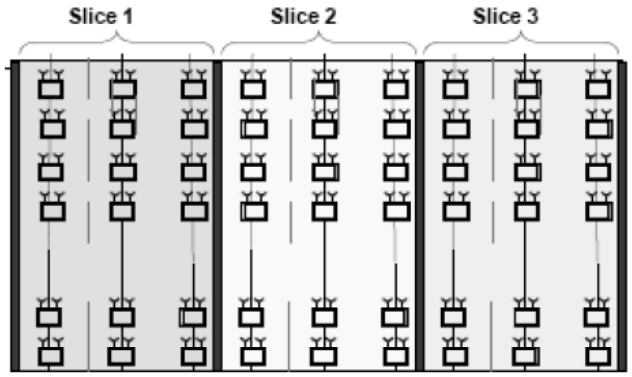



TDMA

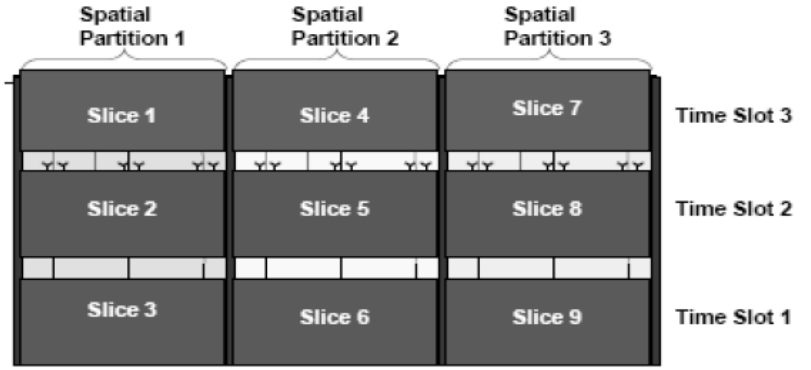


# Combinatorial manner

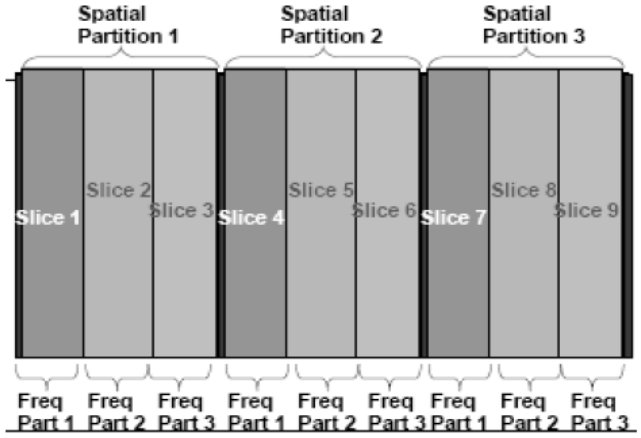
SDMA



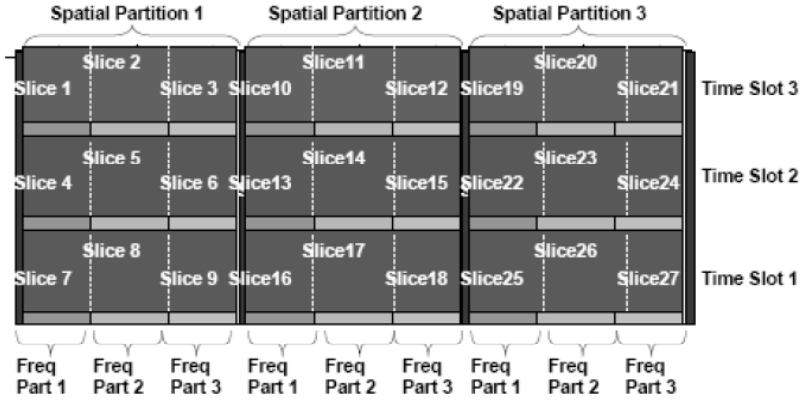

SDMA+TDMA




SDMA+FDMA




SDMA+TDMA+FDMA

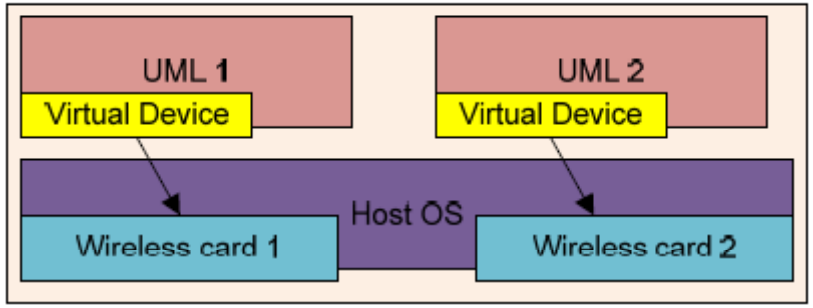


FDM

# Frequency division multiplexing

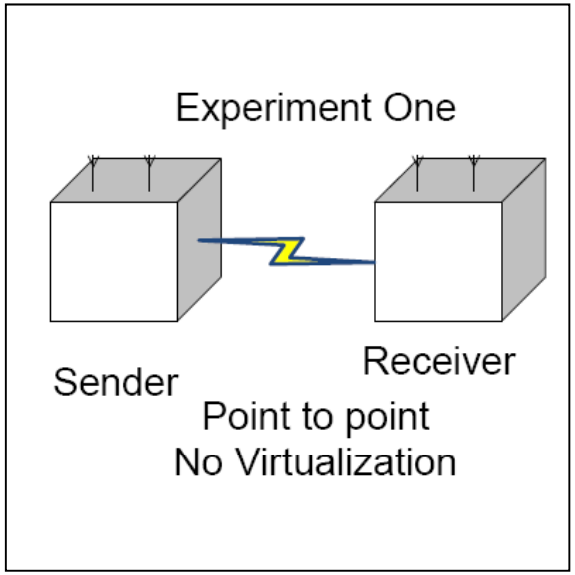
- Scalability is limited by
  - Number of orthogonal channels
  - Channel switching delay
    - Eliminated by multiple wireless interfaces
    - Interference issues

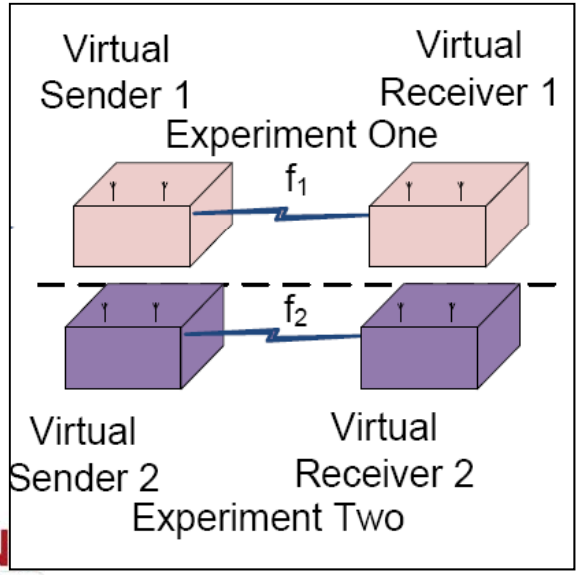
- Exclusive access to a radio using virtualization platforms
  - User Mode Linux (UML), VMWare, XEN etc.

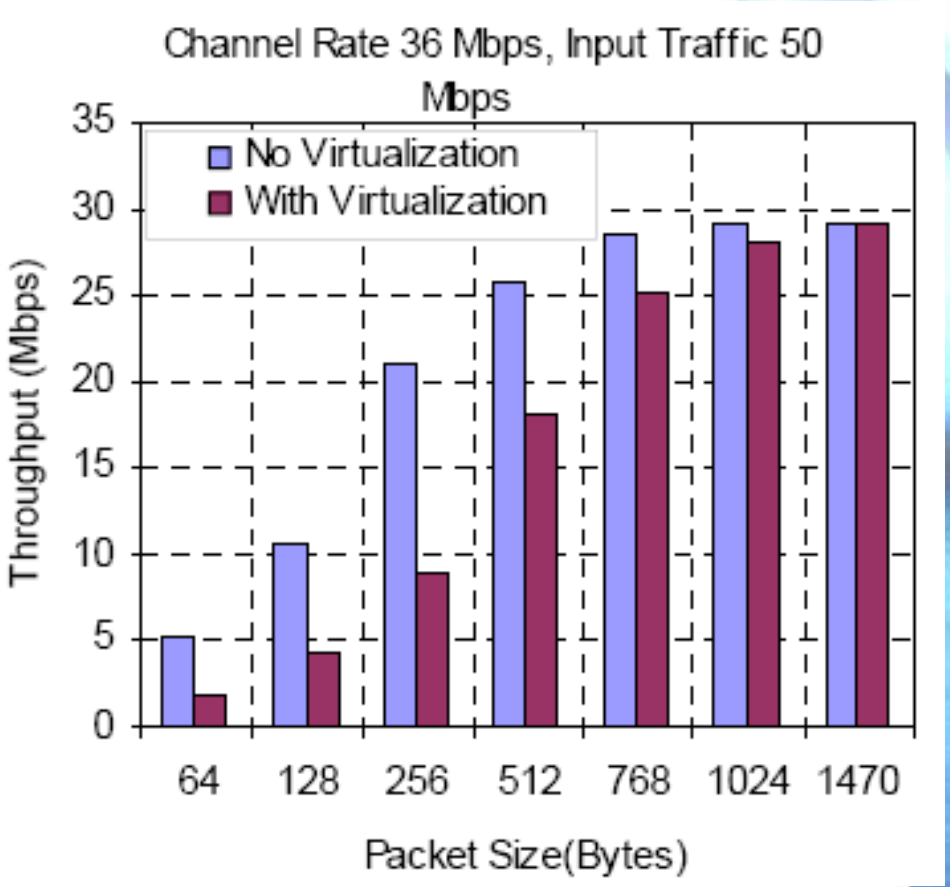


FDM

# FDM using UML(1): Packet size

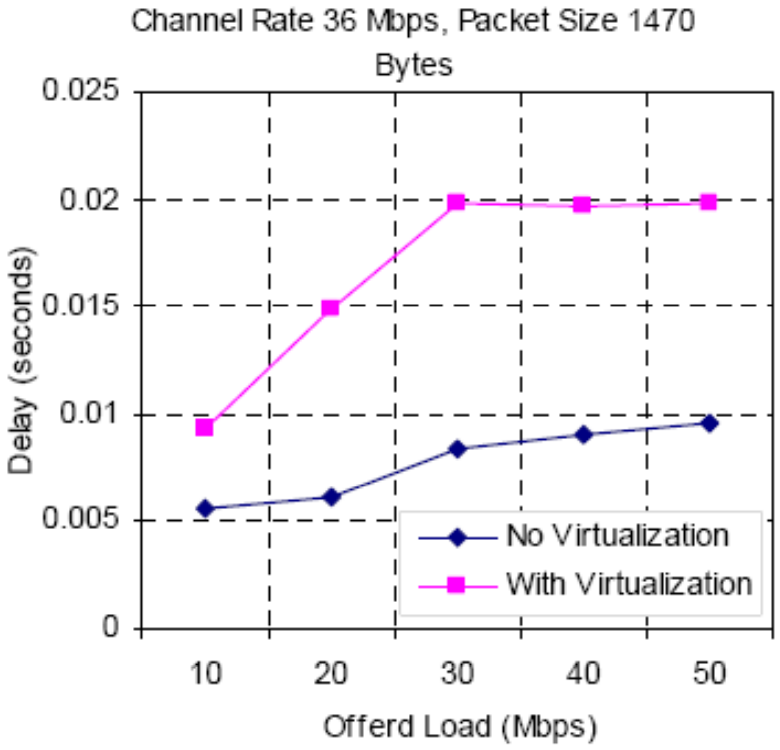


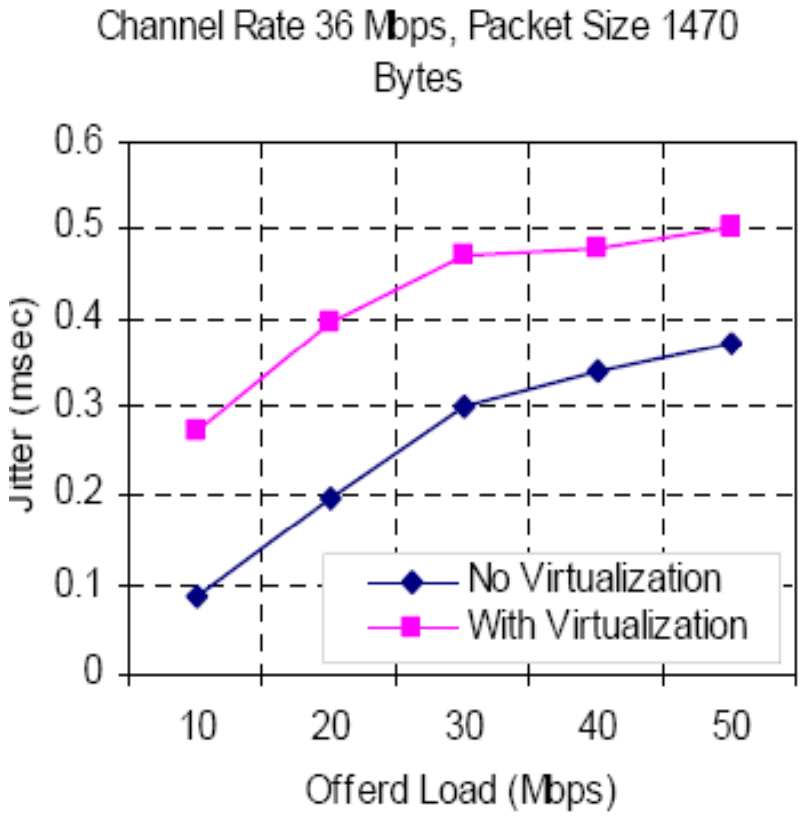



FDM

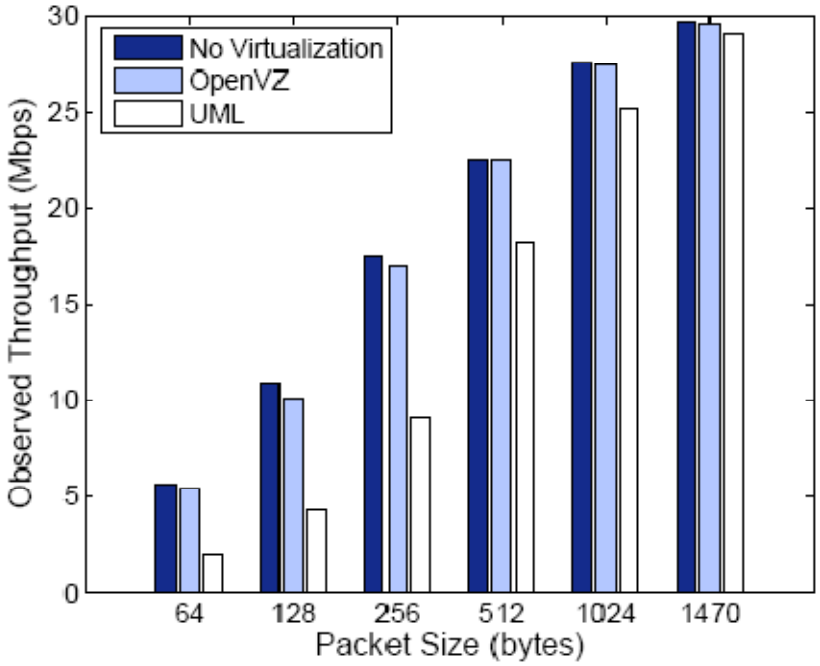
# FDM using UML(2): Delay & Jitter

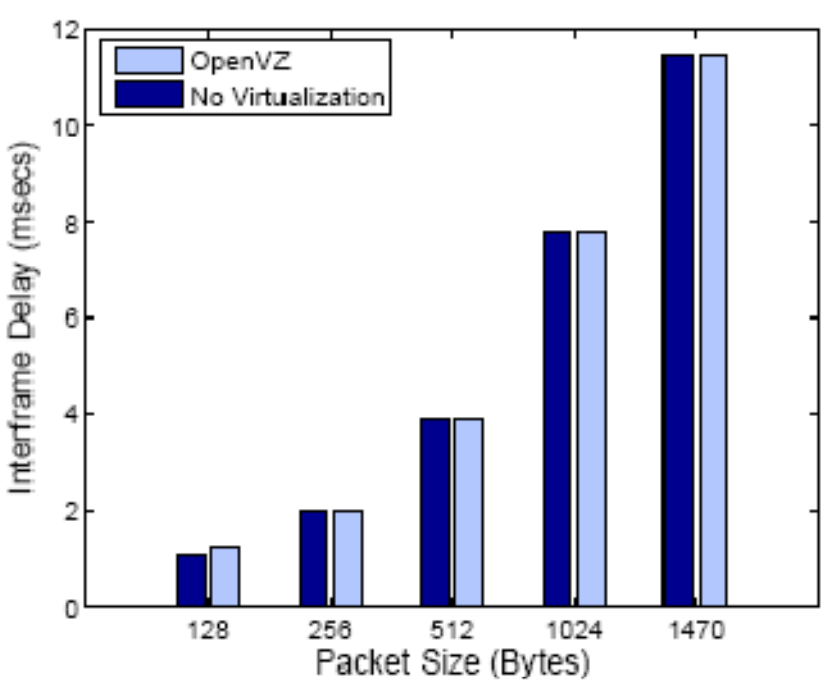


FDM

# FDM using UML vs. OpenVZ

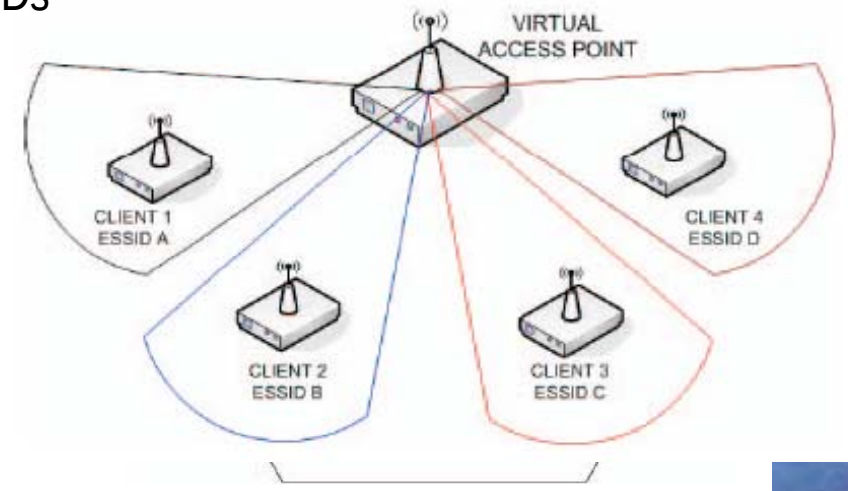



(b) Interframe Space Vs Packet Sizes.

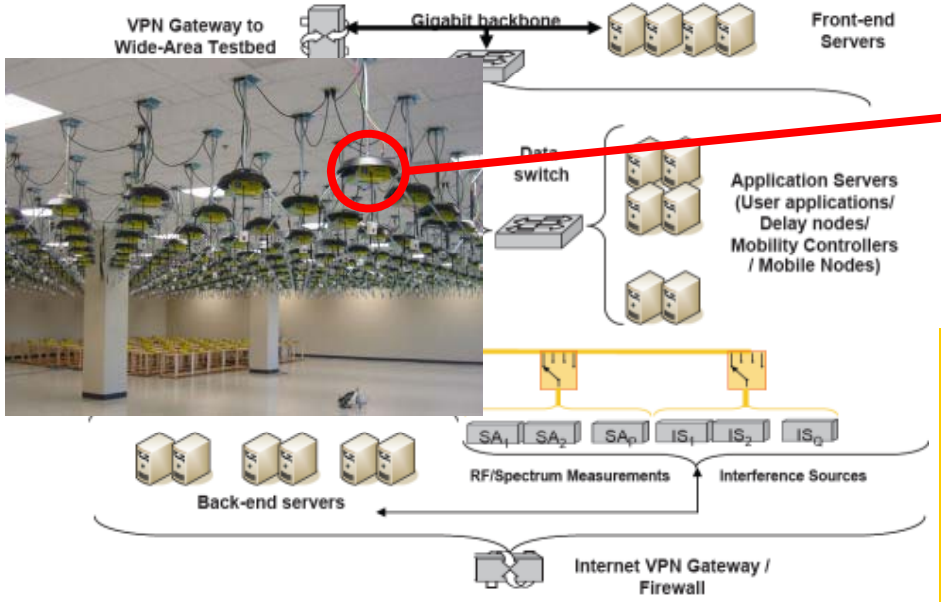
# Time division multiplexing

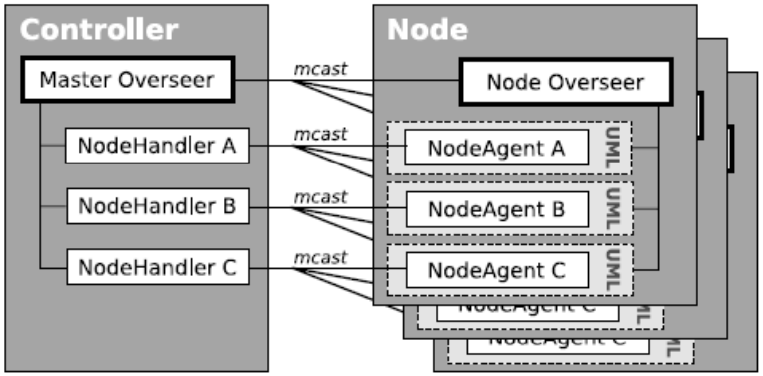
- Explicit TDMA
  - Synchronization
    - NTP(Network Timing Protocol) for distributed time synchronization
  - Context switch: Delay, Clear medium problem
  - Time slot allocation
- Virtual AP
  - Logical partitioning based on ESSIDs
  - Minimize channel conflicts
  - Higher utilization
  - Cost-efficient
    (deployment and management)
  - Fixed star topology
  - Uplink contention
  - Traffic shaping



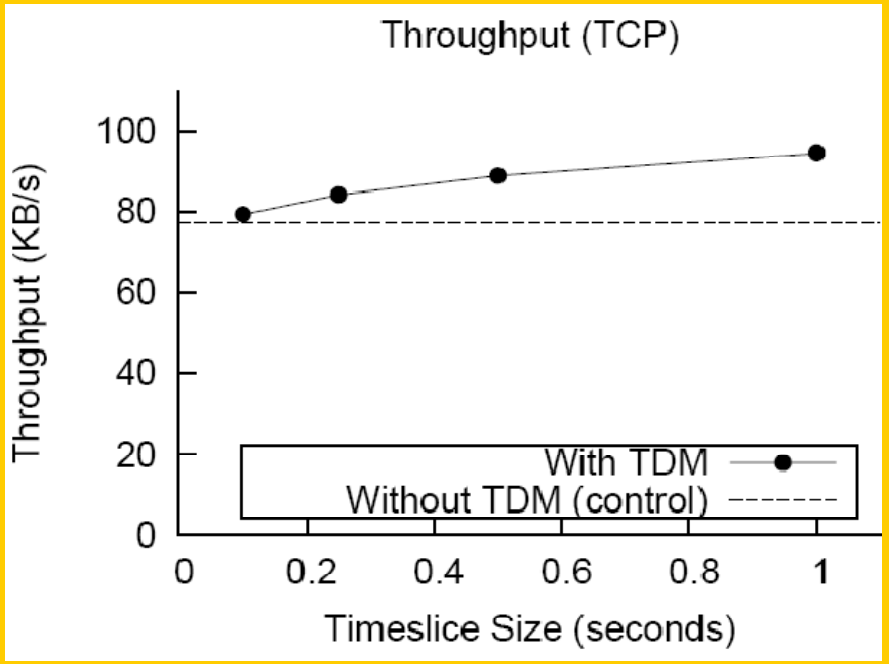
TDM

# Explicit TDMA: Clear Medium Problem



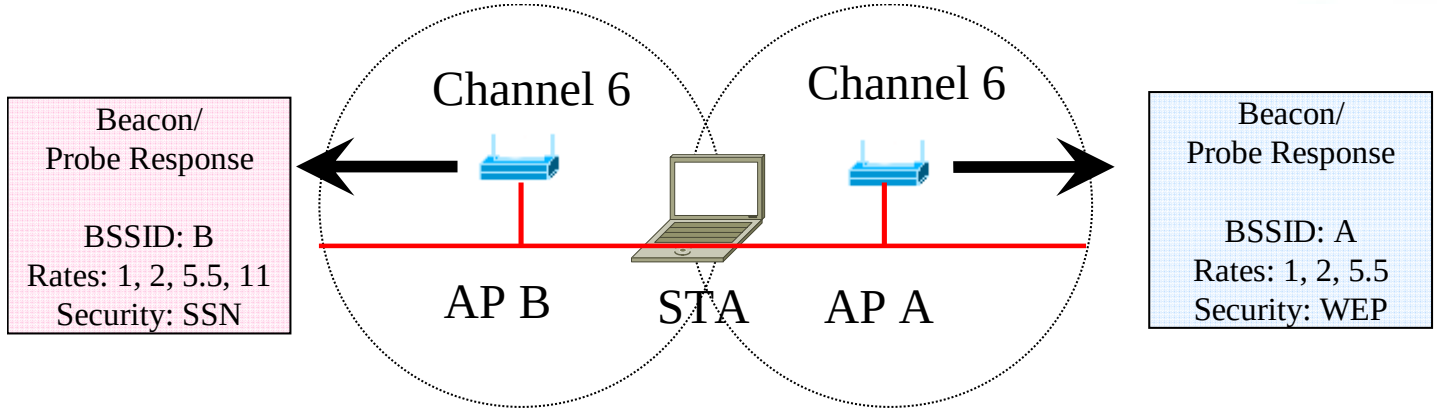




- Performance distortion of TDM

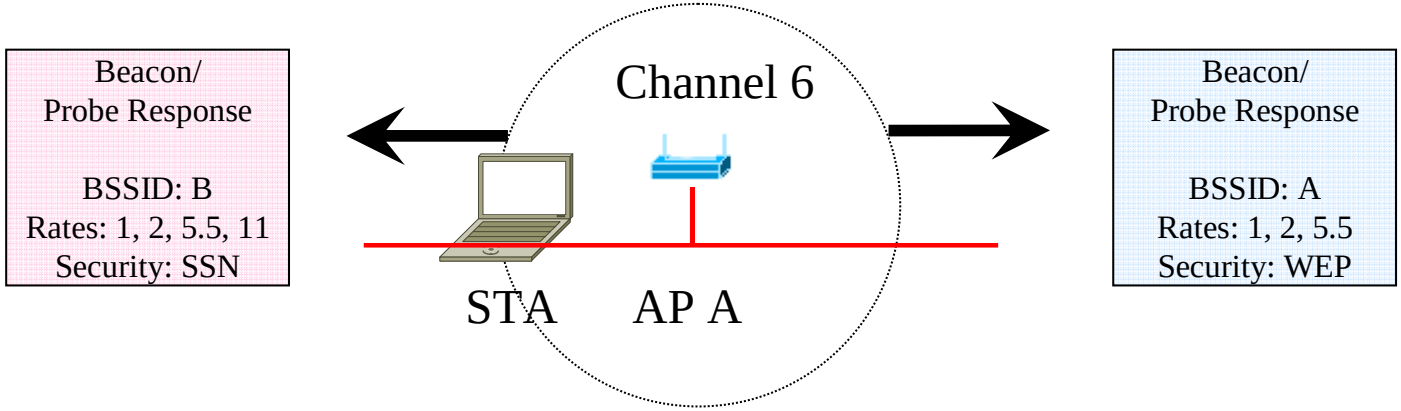


TDM

# Virtual AP




Multiple Physical APs




Multiple Virtual APs

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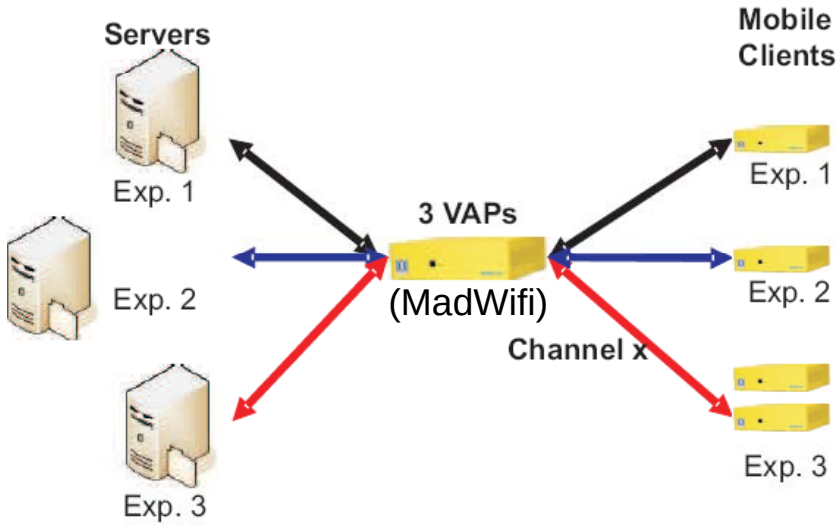
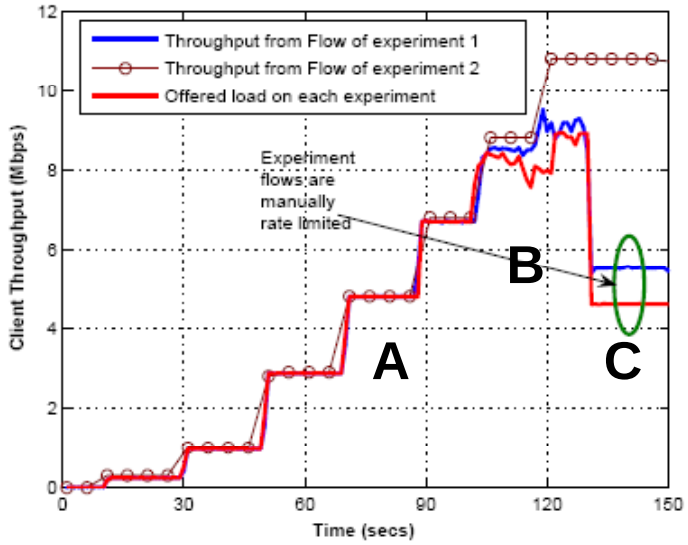
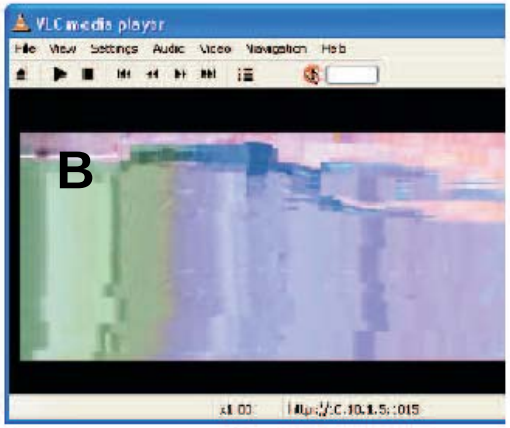
TDM

# Traffic Saturation over VAP



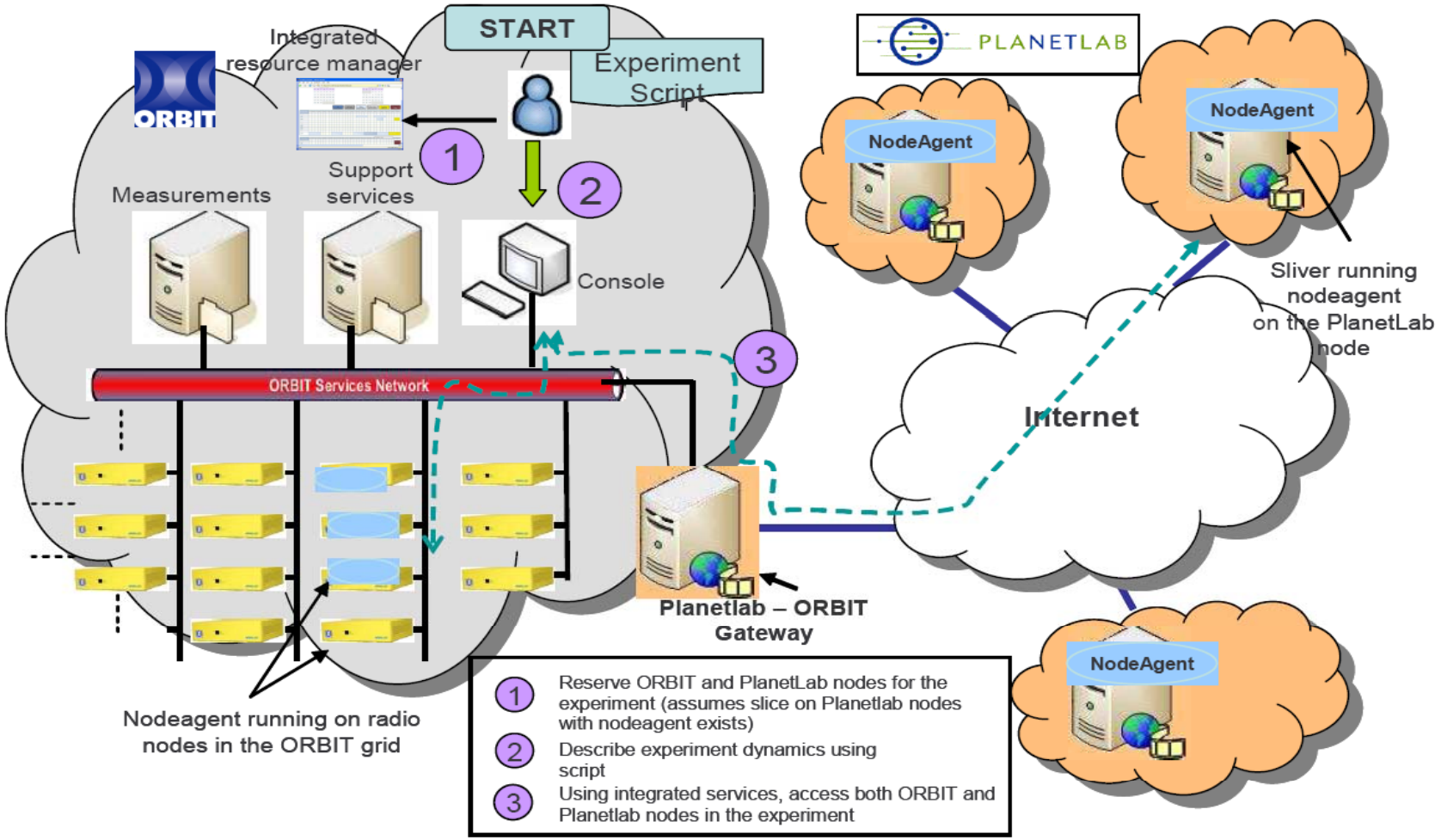





TDM

# Wireless & wired testbeds federation

## ORBIT Driven Integration



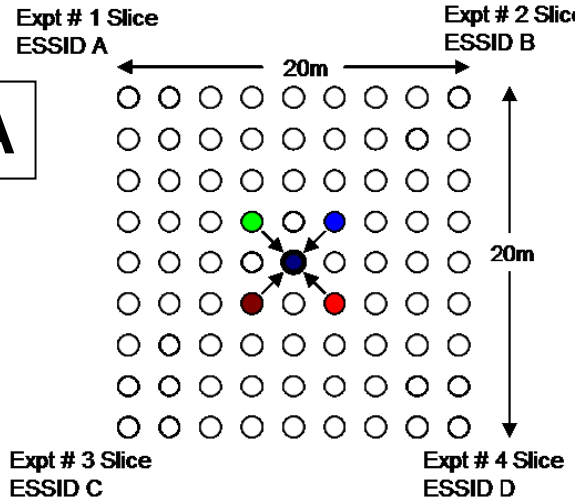
# Space division multiplexing

- In a limited area, interference can not be avoided
- Artificial stretching of distance
  - Transmission power control
    - Spatial separation needed
  - Noise injection

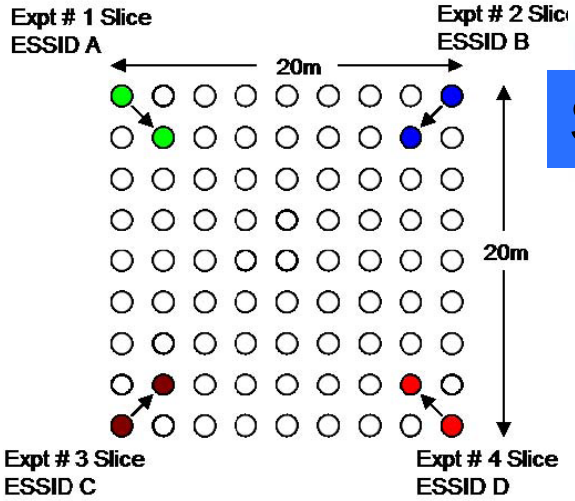
SDM

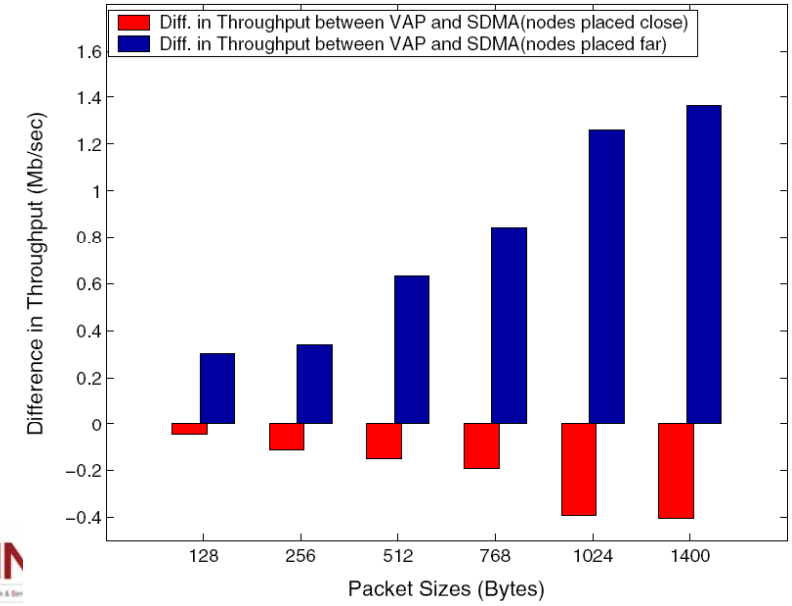
# TDMA(VAP) vs. SDMA(TPC)

TDMA

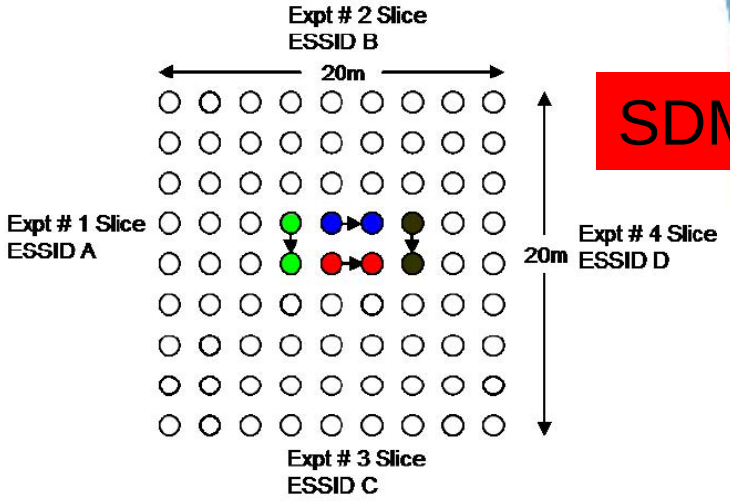



SDMA




SDMA



# OpenFlow Wireless :OpenRoads



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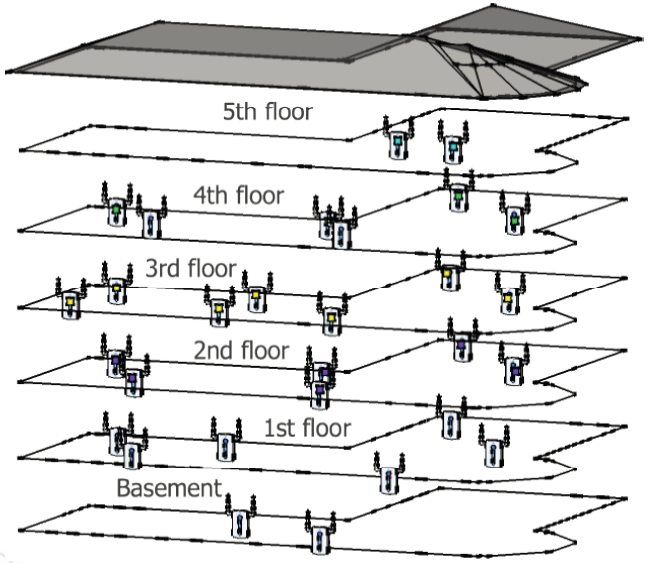
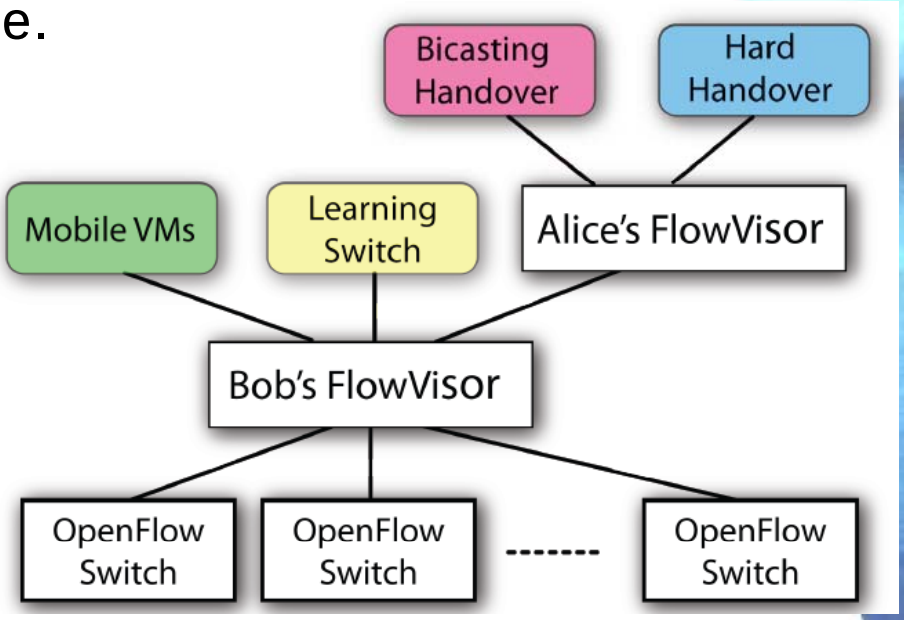
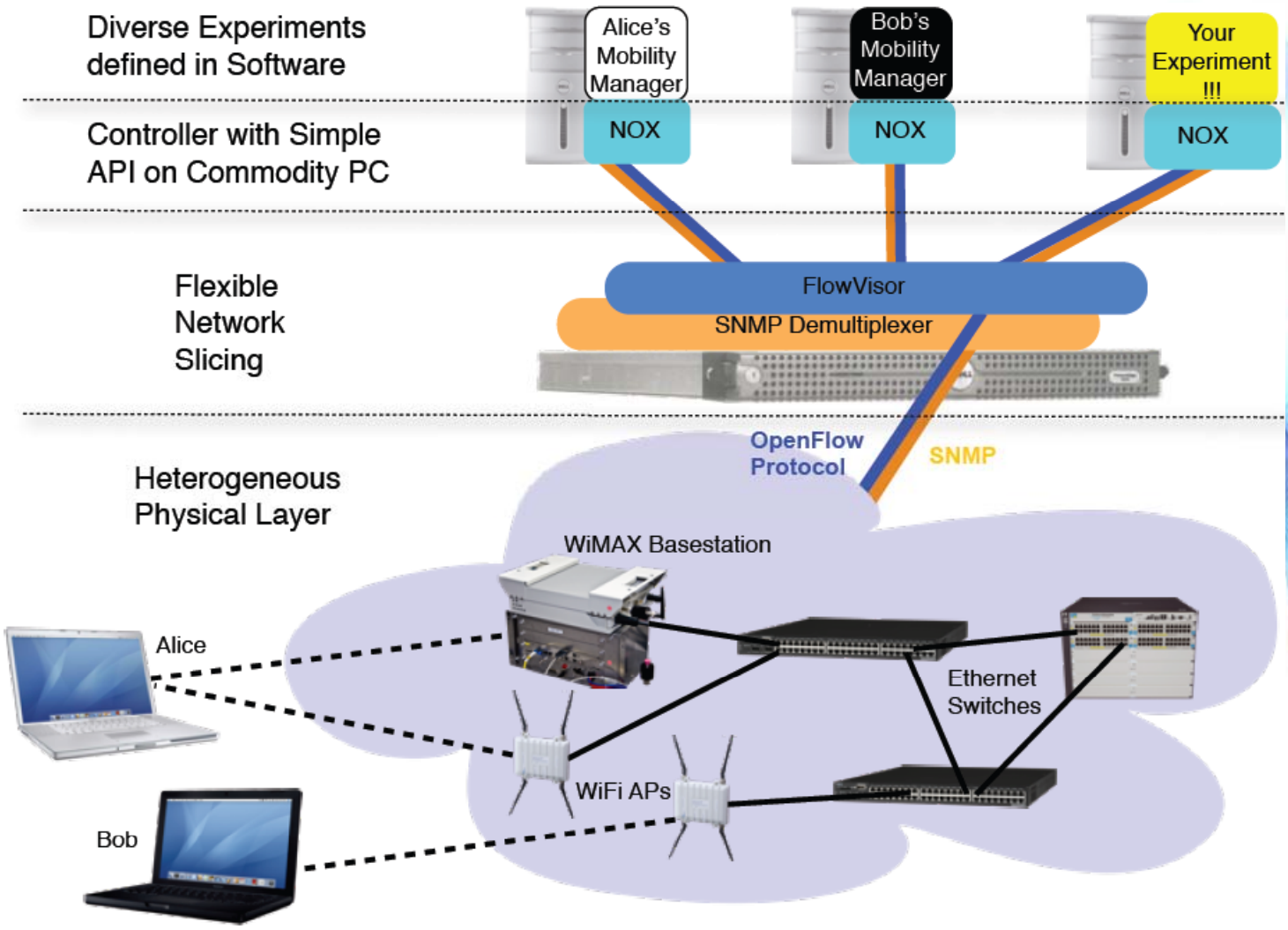
# OpenFlow Wireless: OpenRoads

- Add OpenFlow to switches, APs, and basestations
  - Stanford deployment: 85 WiFi APs and 2 WiMAX BSs
- Heavy research on mobility
  - Hard handover, informed handover, n-casting and Hoolock.
  - How different researchers could create and run their mobility manager at the same time.



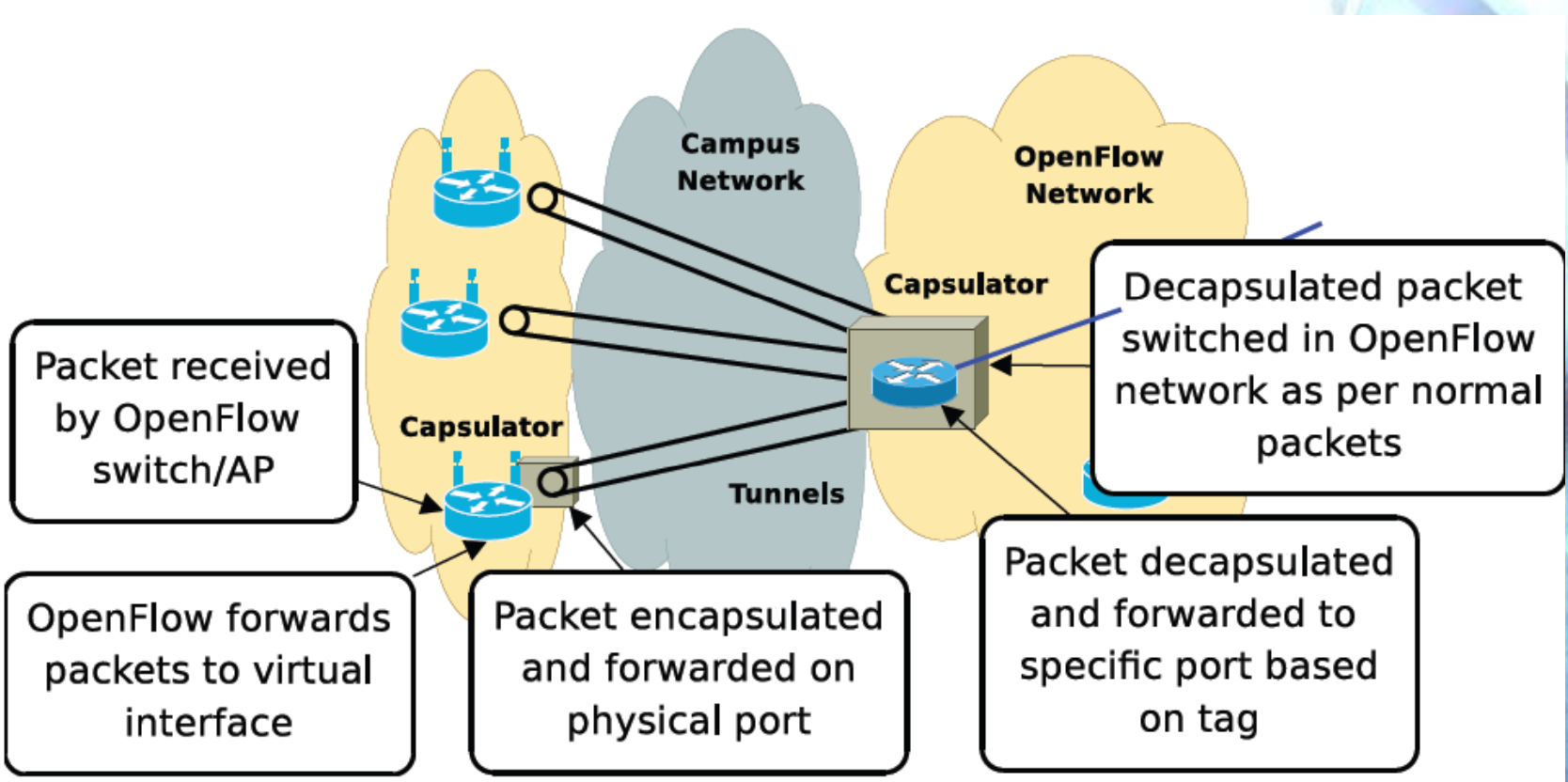
# OpenRoads Architecture



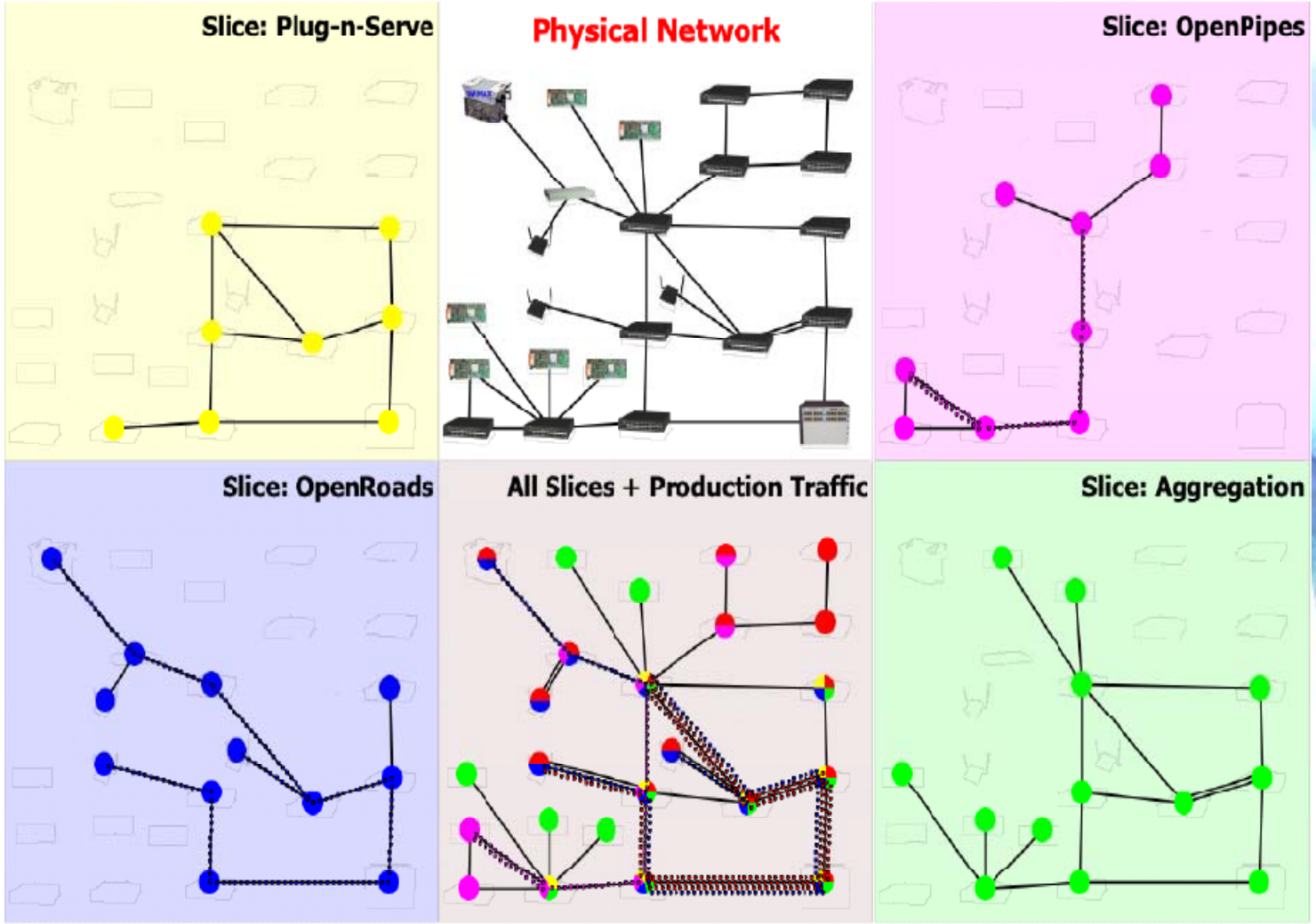

SNU INC lab.

# Capsulator

- OpenFlow-enabled WiFi access points spread across the campus

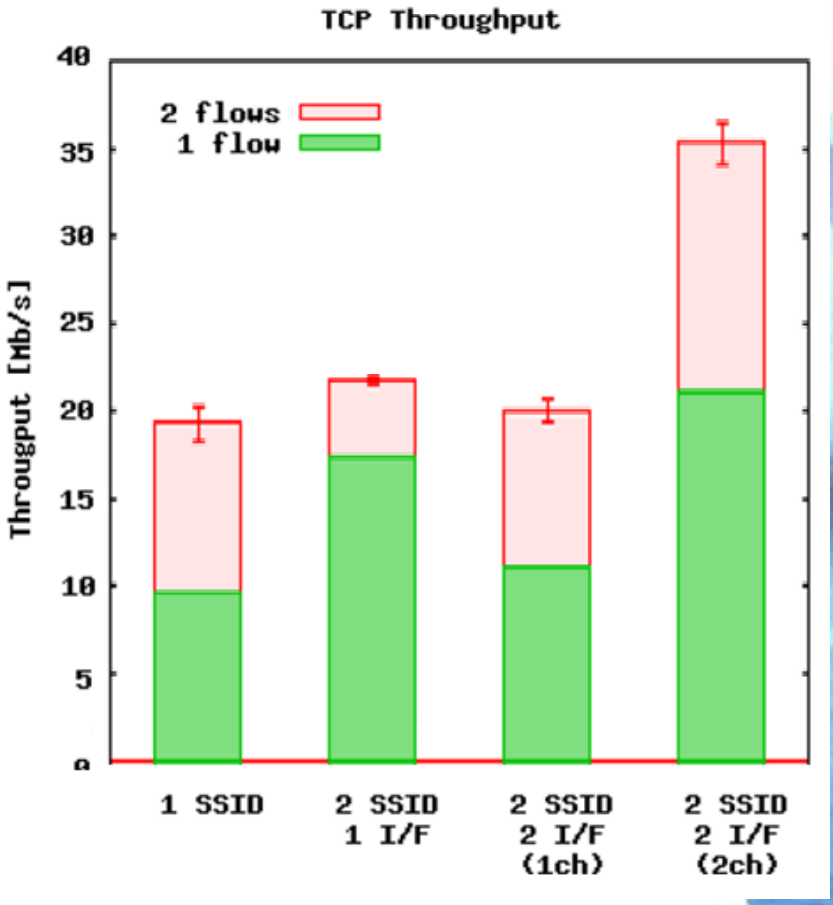


# Multiple experiments



# Performance with Multiple SSIDs

- **1 SSID:** 2 iperf sessions over a single WiFi
- **2 SSID 1I/F:** 1 iperf session over each of 2 virtual WiFi interfaces
- **2 SSID 2I/F (1ch)** 1 iperf session over each of 2 WiFi interfaces
- **2 SSID 2 I/F (2ch)** 1 iperf session over each of 2 WiFi interfaces (ch1, ch11)



# Summaries

- ORBIT testbed virtualization efforts
  - Frequency division Multiplexing
  - Time division Multiplexing : VAP
  - Space division Multiplexing : TPC

- OpenFlow Wireless: OpenRoads
  - OpenFlow enabled APs, BSs, Switches

# Thank you!

# Q&A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