

Virtualization in Wireless Networks

Feb. 23th, 2009

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Outline

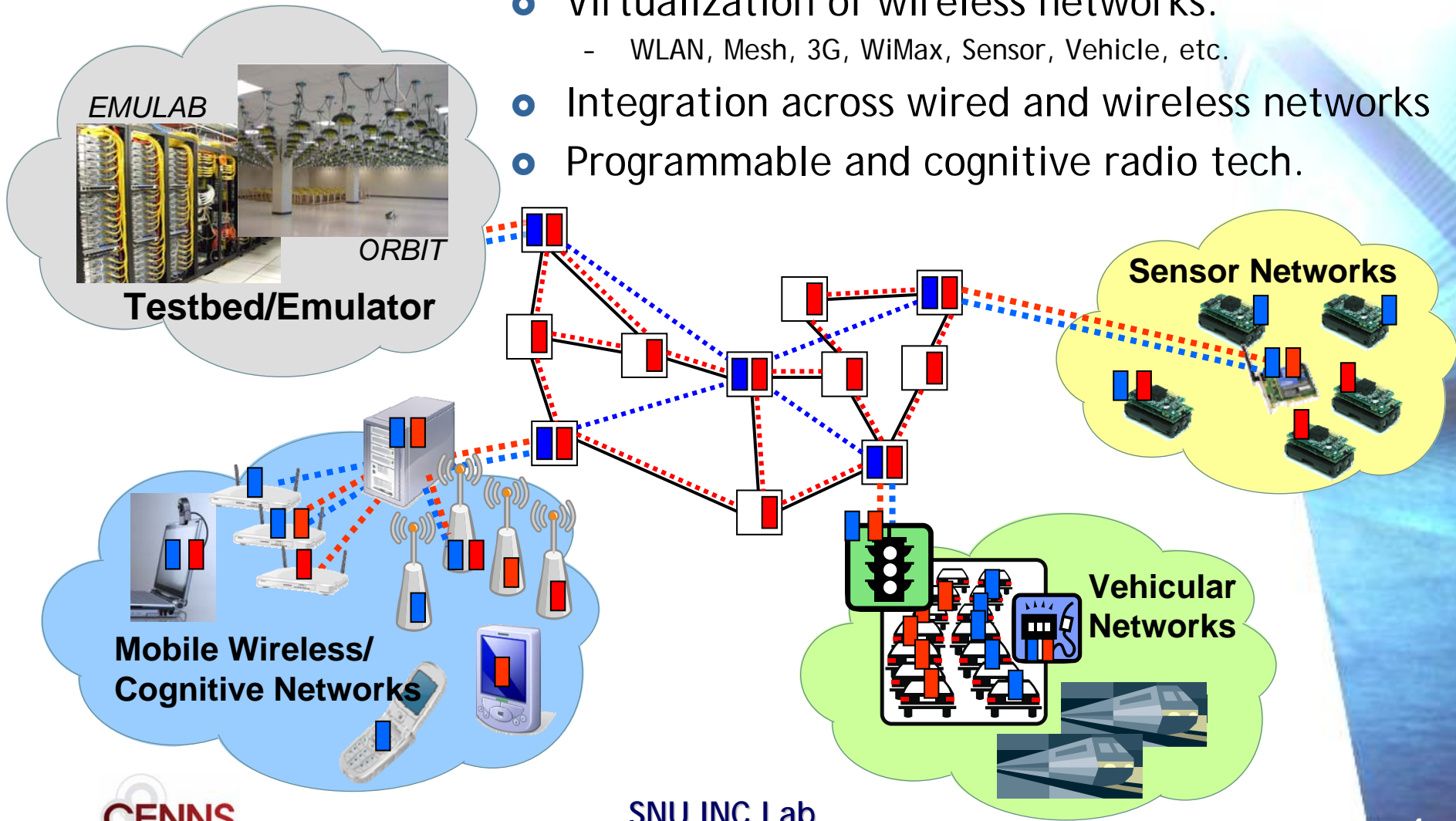
- Introduction
- Examples: WLAN virtualization
- Techniques: Wireless resource isolation
- Embedding problem for wireless virtual networks
- Conclusions

Introduction

- Network virtualization
 - Decoupling network service from network infrastructure
 - *Multiple & independent* network services on a single shared infrastructure
- Research issues
 - To implement Virtual Network: How to slice network resources
 - To manage Virtual Network: How to operate after slicing
- Wireless virtual networks
 - The wireless extensions to the wired virtual networks
 - Wireless virtualization can provide a simple solution for previous problems: [Mobility](#), [Security](#), [Address space](#), [Network management](#), etc.

GENI wireless sub-networks

- Virtualization of wireless networks:
 - WLAN, Mesh, 3G, WiMax, Sensor, Vehicle, etc.
- Integration across wired and wireless networks
- Programmable and cognitive radio tech.

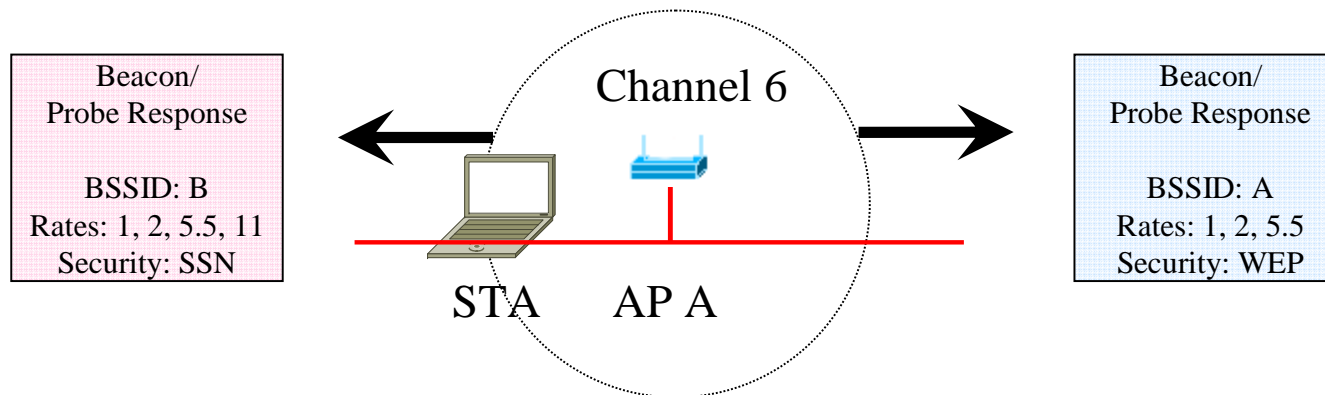


Wireless Virtualization Example: WLAN Virtualization

Multiple VAPs over one physical AP
One VAP made of multiple physical APs

Multiple VAPs over one physical AP

- Virtual AP
 - Multiple ISPs/Services using the existing APs
 - VMAC: virtual MAC address
 - Enhanced resource utilization
 - Cost-effective approach
 - Without considering resource isolation

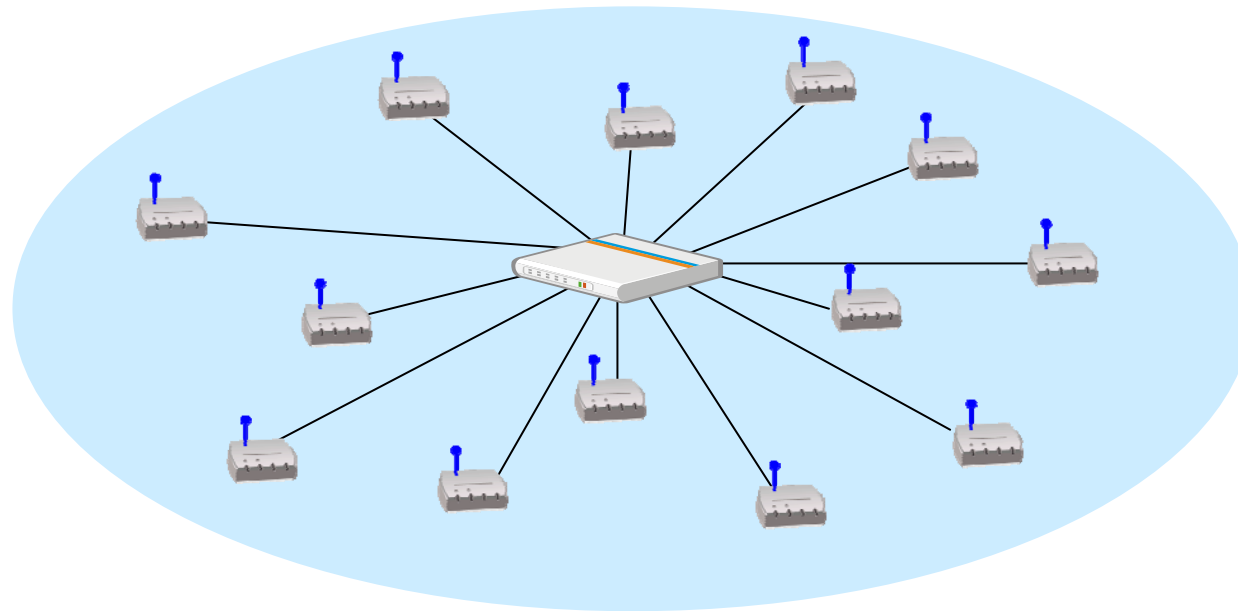


Multiple Virtual APs

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Channel blanket topology

- Multiple thin APs supporting a single cell controlled by a central server
- Interference/handoff free system
- Scalability problem



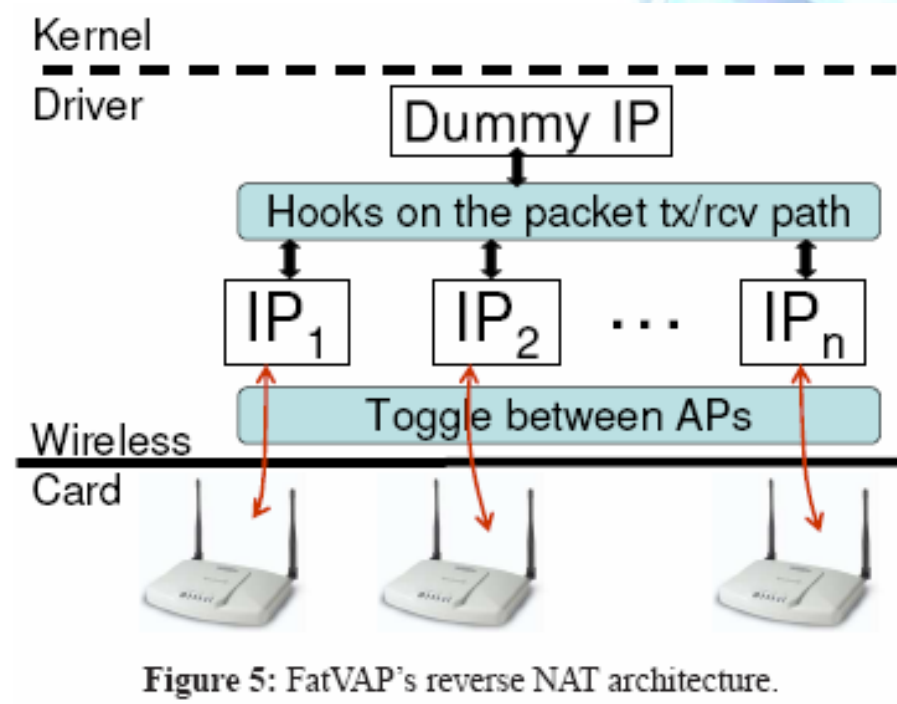
FatVAP [Katabi'08]

- Split the traffic of a MN over multiple APs



Fat AP emulation

- Kernel maps flows with interfaces according to routing info.
 - Reverse NAT architecture replaces source IP address
 - MN side virtualization
- Useless if the wireless medium is a bottleneck



Wireless Virtualization Techniques: Wireless Resource Isolation

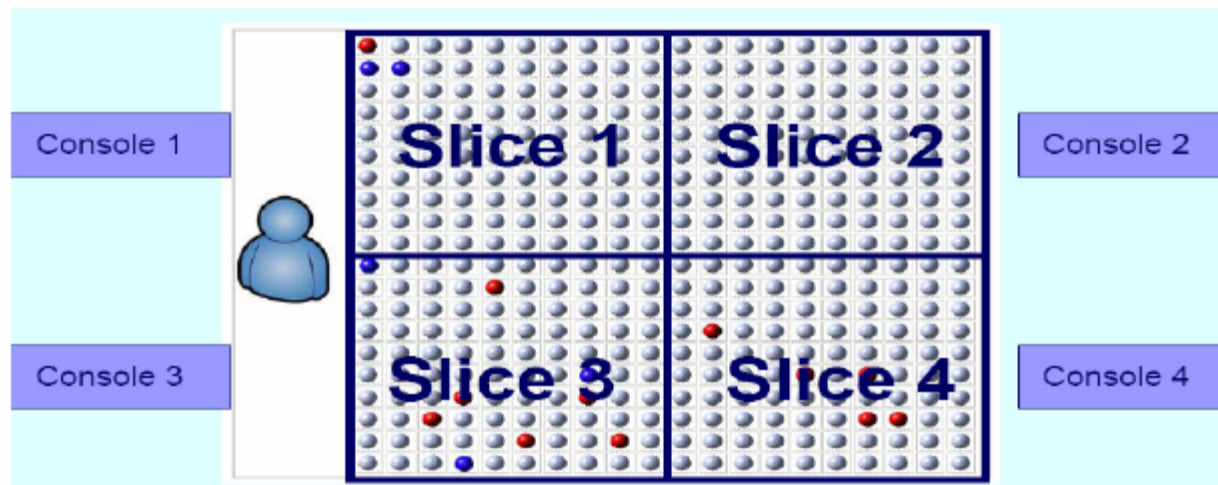


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Virtualization Tech.(1/4)

- SDMA

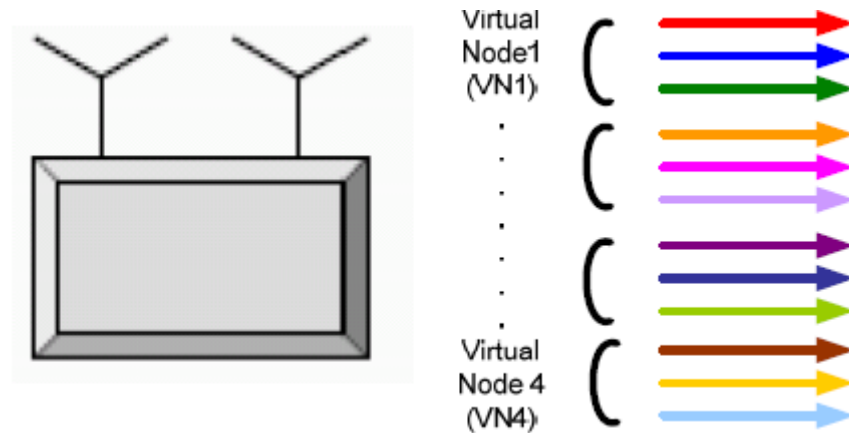
- Each experiment is assigned space
- Size of region controlled by transmission power, channel characteristics, etc.
- Transmit power control is important



Virtualization Tech.(2/4)

- FDMA

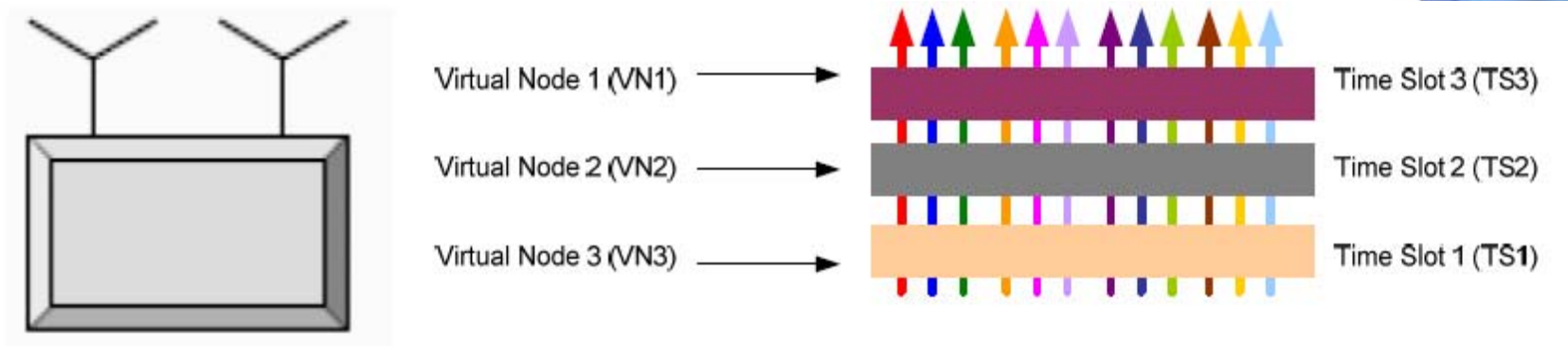
- Different experiments assigned non-interfering channels
- Limited number of non-interfering channels
- Channel switching time
 - Can be avoided using multiple NIC cards



Virtualization Tech.(3/4)

- TDMA

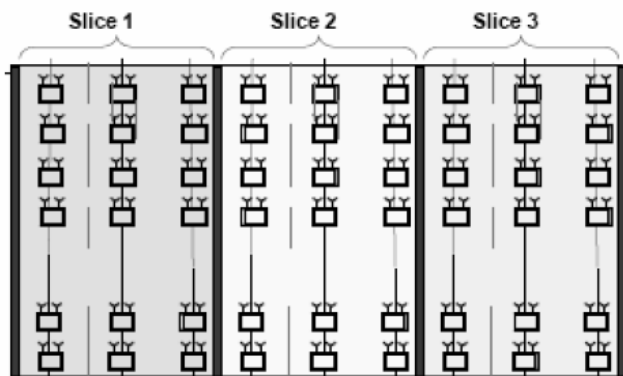
- Each experiment is assigned time slots
- Context switching overhead
- Time synchronization



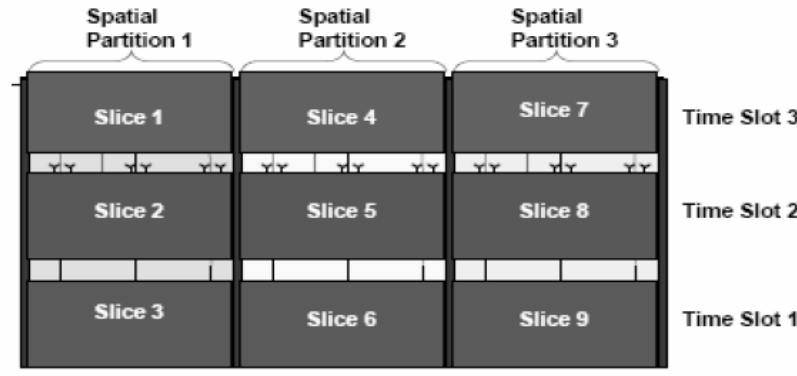
Virtualization Tech.(4/4)

- Combinatorial manner

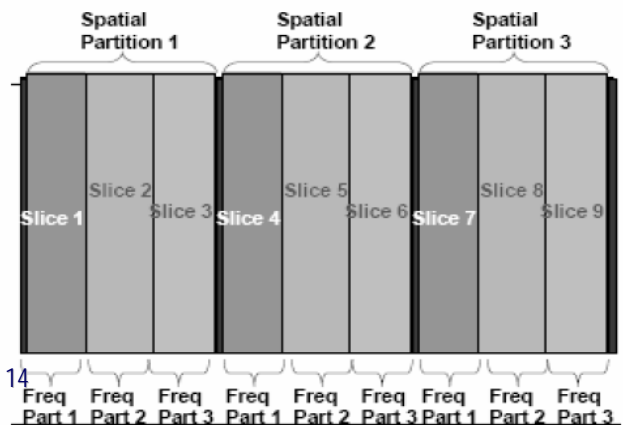
SDMA



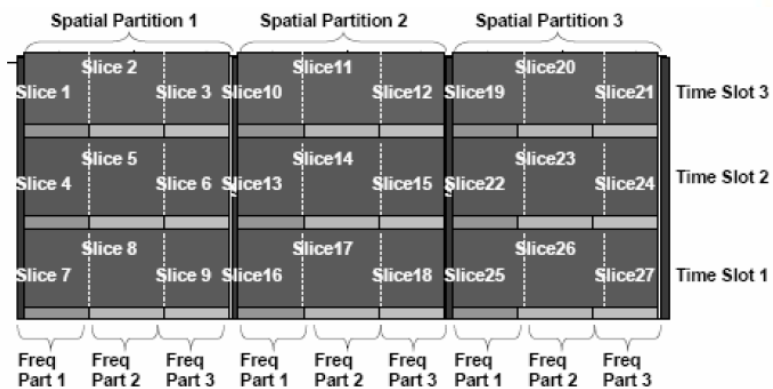
SDMA+TDMA



SDMA+FDMA



SDMA+TDMA+FDMA



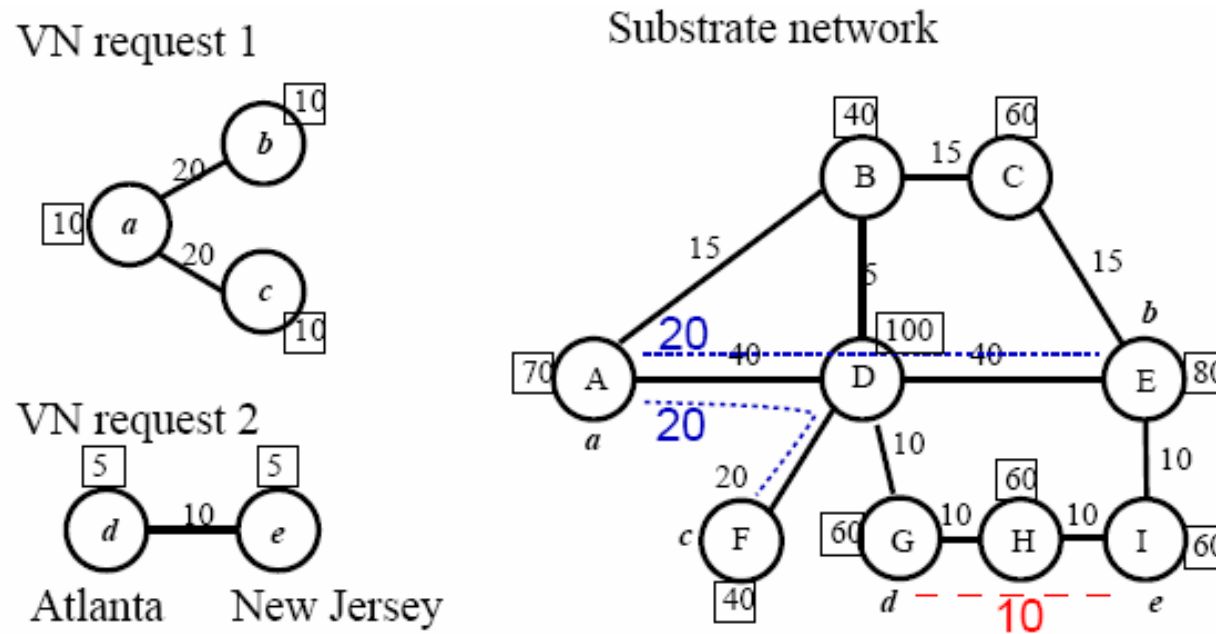
Embedding Problem for Wireless Testbed



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Virtual network embedding problem

- Mapping logical slices into physical substrates

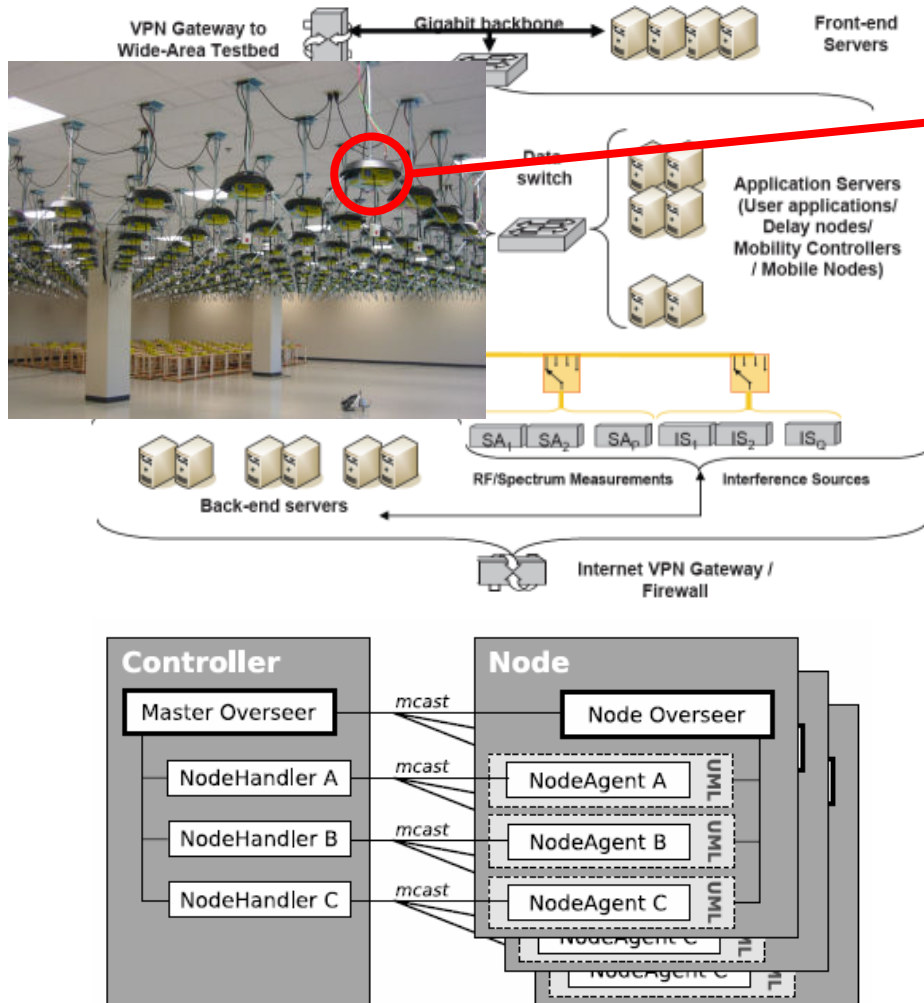


Wireless testbed

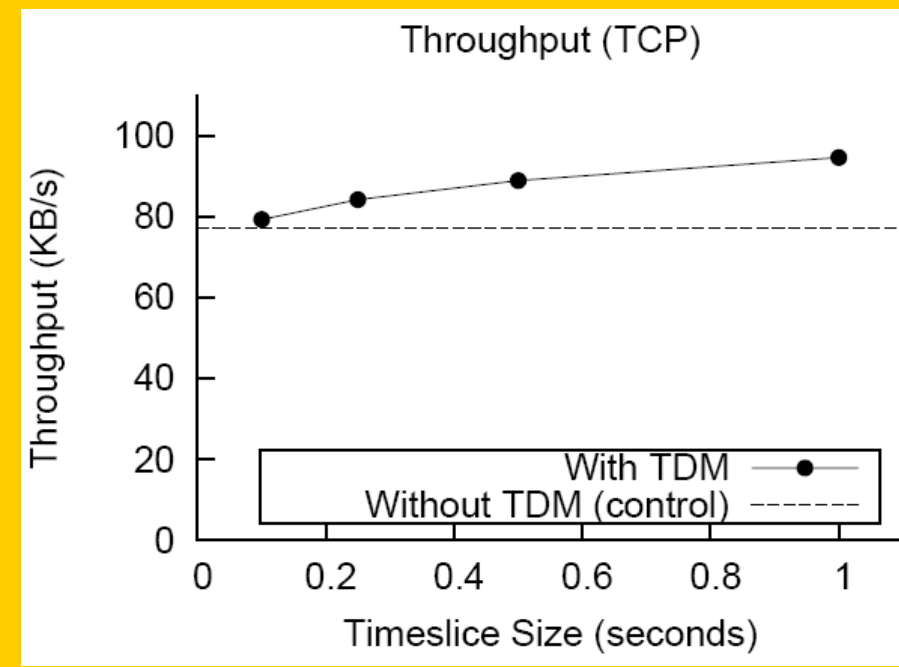
- Examples
 - ORBIT, Emulab, etc...
- ORBIT
 - Nodes are placed in **Grid**
 - Nodes have **Multiple Wireless Interface** cards
 - 2 transceivers per node
 - The number of channels > the number of interfaces
 - Slicing by **FDM+TDM+SDM** is
 - Referred by Tech. report from



TDM based virtualization of ORBIT

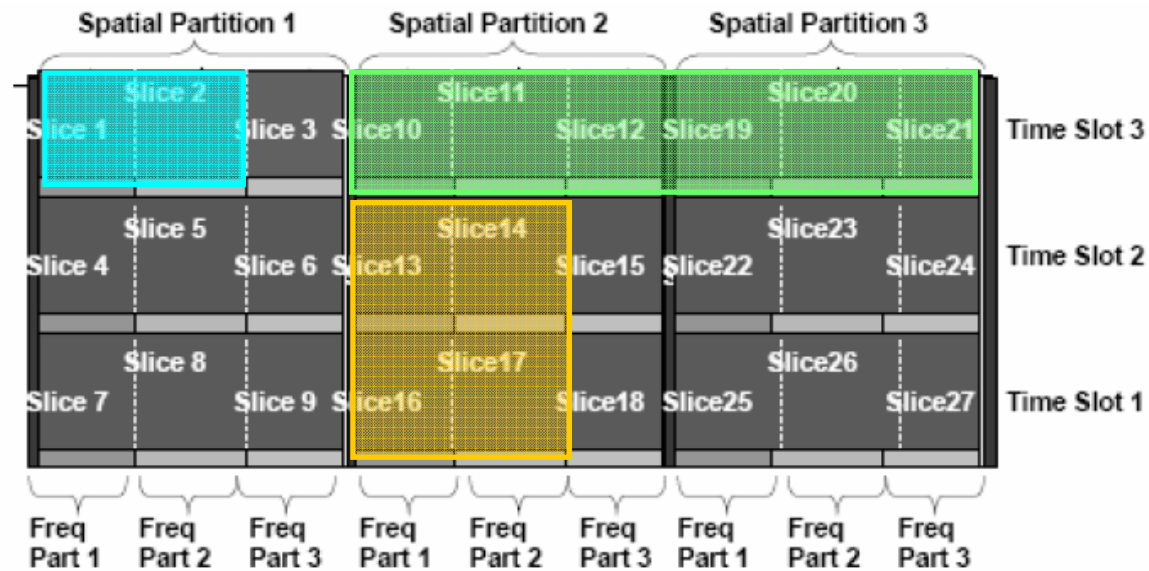


Performance distortion of TDM

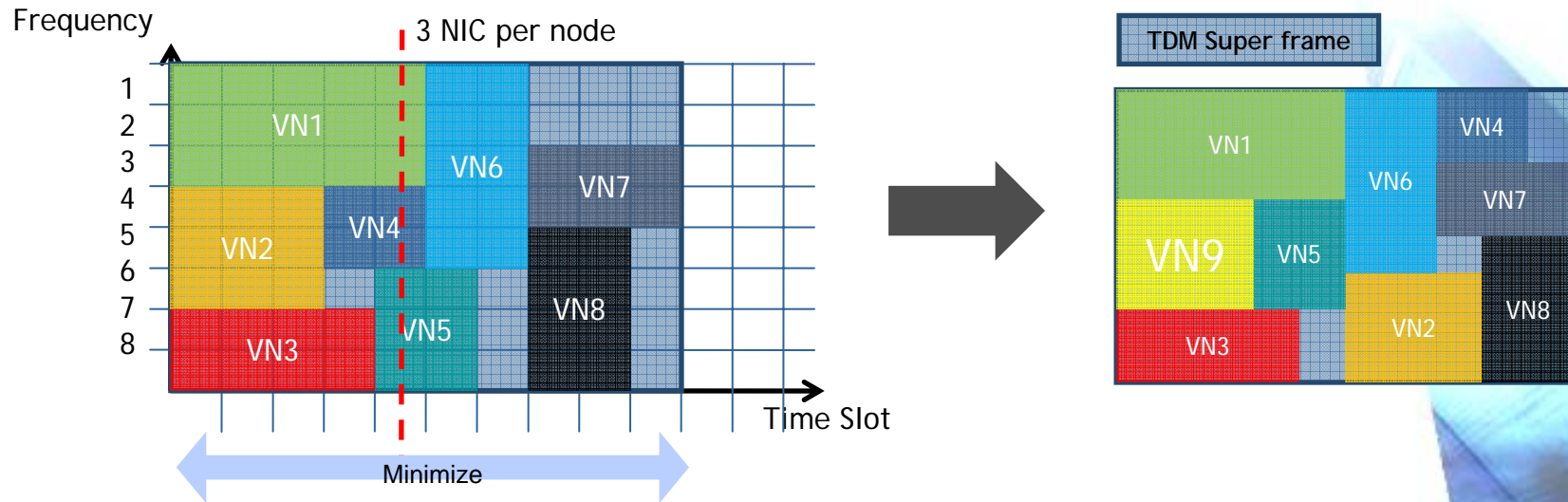


Embedding for wireless virtualization

- Slice requirements for wireless testbed
 - Various number of frequencies and interface cards
 - Various time length and space size
- Goal
 - Accommodate as many VNs as possible, while meeting the constraints of each VN's requirement



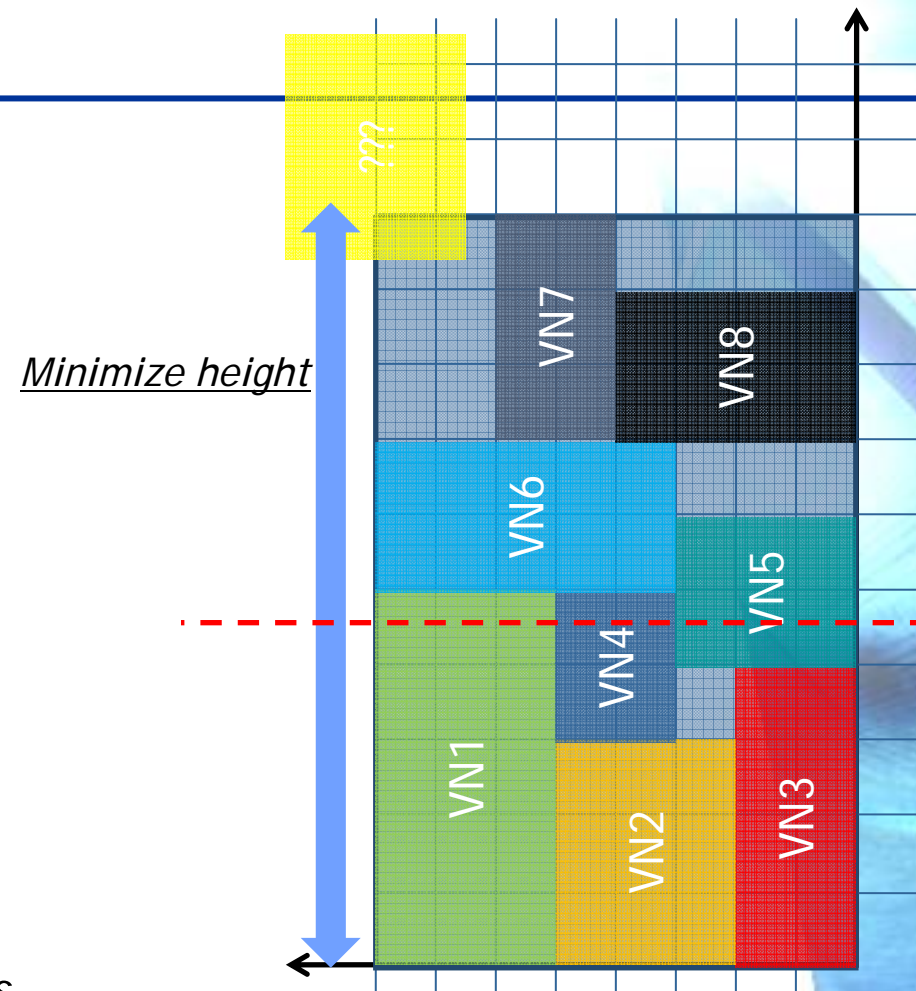
Problem description



- Assumptions
 - TDM + FDM (A slice is defined by the duration of time and the number of channels)
 - A single radio interface is allocated to each slice
- Similar to **2D packing problem**
 - but it must meet MSC (Maximum Slicing Constraint)
- Goal: minimize the super frame length

Packing problem

- Problem type
 - 2D knapsack problem
 - Strip packing problem
 - Bin packing problem
- Solution type
 - Exact solution
 - NP-complete
 - Approximation
 - heuristic
- Additional constraints
 - The number of transceivers
 - Segment of channel dimension $<$ the number of transceiver



Simulation results

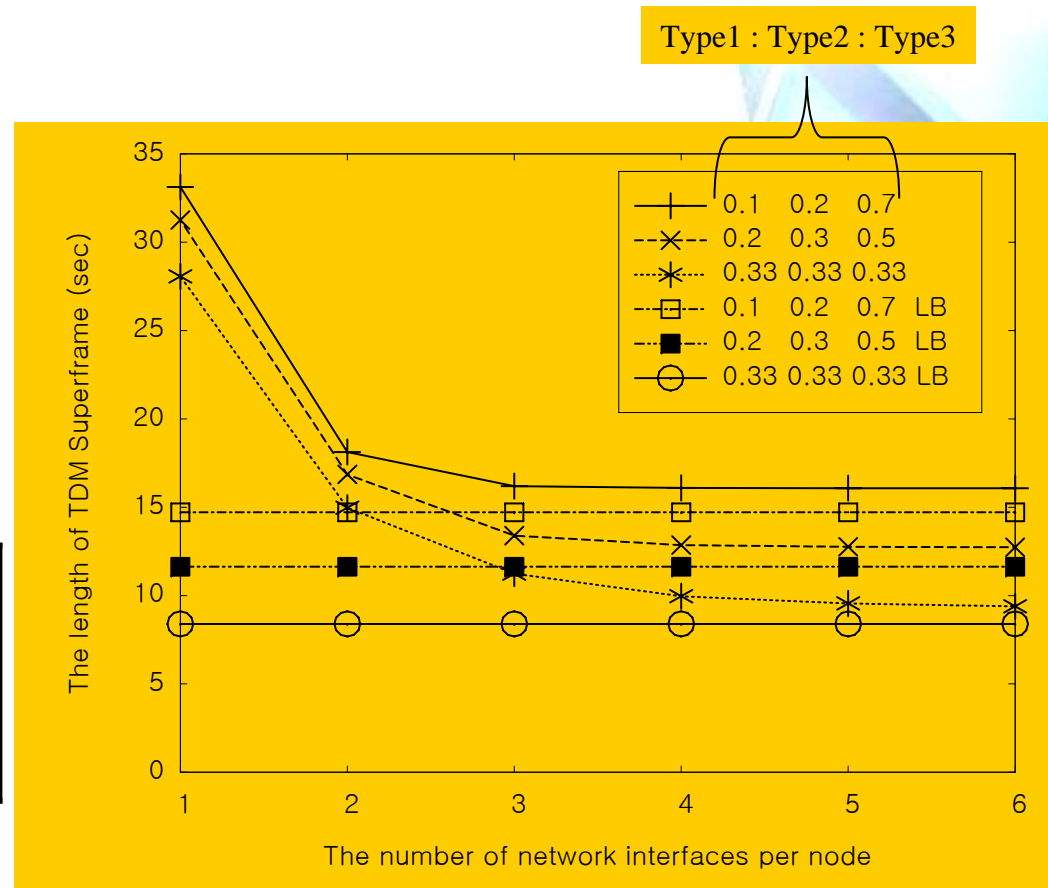
● Metric

- TDM Super-frame length
- Low Bound

$$LB = \frac{\sum_{i=1}^n Area(S^i)}{W}$$

W: the number of total channels
 S^i : the slice i

	Channel	Time slot	Ch. by Time
Type1	Single	Single	<i>1 by 1</i>
Type2	Single	Multiple	<i>1 by 3~10</i>
Type3	Multiple	Multiple	<i>3~12 by 1~10</i>



Conclusions

- Network virtualization in terms of future Internet allows
 - Various future internet architectures to coexist
 - Testbed to verify various future internet proposals
- Wireless virtual networks
 - The wireless extensions
 - A simple solution for previous problems:
 - **Mobility, Security, Address space, etc.**
- Two ways of virtualization: WLAN examples
- Wireless virtual network embedding problem

Thank you!

Q&A



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