

Virtual Radio Networks

A Framework for Configurable Radio Networks on Shared Infrastructure

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Innovation Cycles in Radio Networks

- Constant innovation in wireless transmission
 - MIMO, cooperative transmission, relaying, ...
 - routing, mobility management, multicast, ...
 - ➔ ... but it takes long time before real deployment (if at all)

- Why ?
 - Long development cycles
 - complexity (large scale distributed systems)
 - backwards compatibility
 - consensus-building and standardisation
 - Economic barriers
 - Large up-front investment for network build-out

New solution paradigm

- Long development cycles
 - complexity (large scale distributed systems)
 - backwards compatibility
 - consensus-building and standardisation

- Concurrent existence of different radio network solutions
- Reconfigurability of radio networks

- Economic barriers
 - Large up-front investment for network build-out

- Re-use and sharing of existing infrastructure

→ *Virtual Radio Networks*

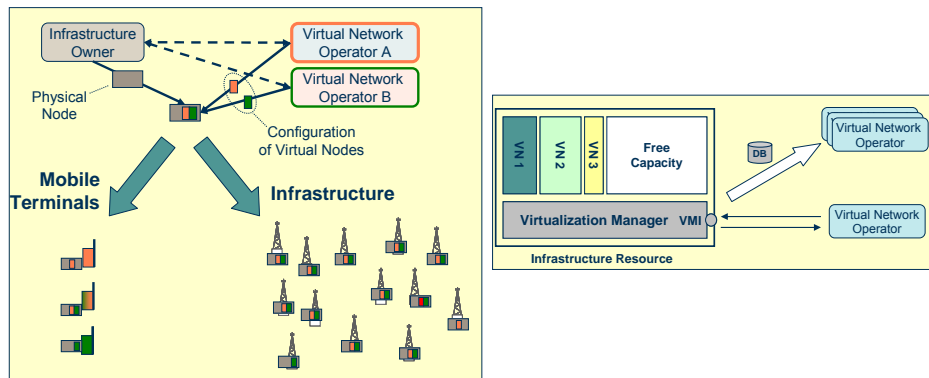
Related Work

- Virtual Networks (mainly fixed networks)
 - considered as design principle for Future Internet design
 - large scale experimental systems (e.g. GENI)
 - concurrent operational networks (e.g. CABO, 4WARD)
- Reconfigurable Networks
 - for wireless mainly focused on *software defined radio*
 - role-based protocol design, active networking, router virtualization

- Combine Network Virtualization with Reconfigurability
 - Avoid a *dead-end of evolution* by *parallelism*
 - Migration as transition from one virtual network to another one
 - Wireless edge network for *end-to-end virtual networks*

Virtual Radio Networks

- Multiple Virtual Radio Networks on a Shared Infrastructure
 - Determine required nodes
 - Configure virtual nodes
- Mobile devices
 - Can be configurable
 - Can be specific for one/few virtual radio networks (cost efficiency)



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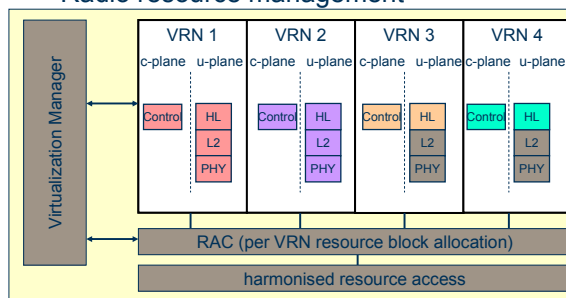
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Virtual Radio Network Configuration

- Any communication method / protocol
 - Routing, mobility management, naming
 - Radio protocols, channel coding, smart antenna steering
 - Cross layer optimization
- Any (VRN internal) management function
- Any (VRN internal) control function
 - Multi-user management
 - Radio resource management



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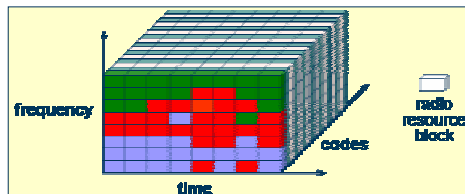
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Radio Resource Allocation

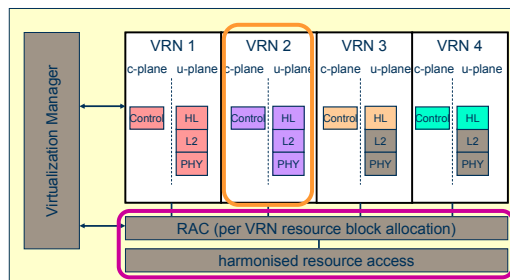
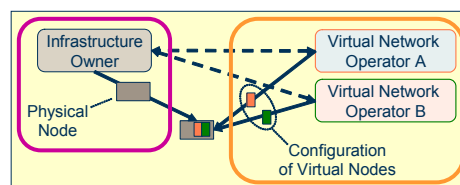
- Different virtual radio networks share radio resources
 - harmonized *radio resource blocks*
 - some limitation on possible physical layer structures of different virtual radio networks
 - generalized form of multiple access (FDMA, TDMA, CDMA)
 - but per *virtual radio network* (not per user !)
 - coordinated via infrastructure node



- ➔ Efficient resource partitioning
- ➔ No interference between virtual radio networks
- ➔ Predictability of available resources per virtual network

New business models & relationships

- Separation of
 - infrastructure provider
 - competition
 - regulation
 - (virtual) network operator
 - customization
 - competition
- Decoupled development life cycles
 - long-term
 - infrastructure
 - capacity
 - short- / mid-term (dynamic and flexible)
 - virtual (radio) network
 - functionality



Examples

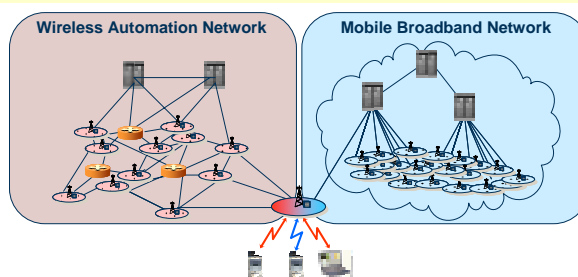
Wireless Automation Network

- Optimised for large quantity of low-rate data (machine-to-machine) services
- Battery-saving transmission of end nodes (sensors/actuators)
- Multi-path mesh routing

Mobile Broadband Network

- Optimised for broadband multimedia services
- Cooperative multi-site transmission for capacity
- Cellular mobility management

Based on same infrastructure



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Challenges for Virtualised Radio Networks

- Performance, scalability and cost-effectiveness of re-configurable radio nodes
- Overhead and efficiency of virtualisation
 - but aggregation of resources possible prior to virtualisation
- Fragmentation of wireless access technologies
 - economy of scale ?

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Summary

- Virtual Radio Networks
 - Logical networks on shared infrastructure
 - Following the network virtualization paradigm of Future Internet research
 - Cost-efficiency
 - re-use and sharing of network infrastructure
 - Flexibility
 - customizable via reconfiguration
 - faster deployment of (e.g. experimental) networks
 - Evolvability
- May lead to new business roles and eco-system
 - separation of *network infrastructure* and *network functionality*

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