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
Related Work

- **Virtualisation** (mainly fixed networks)
  - separation, resources sharing
  - considered as design principle for Future Internet

- **Reconfigurable Networks**
  - for wireless mainly focused on *software defined radio*
  - role-based protocol design, active networking, router virtualization

**Combine Network Virtualization with Reconfigurability**
- Concurrent existence of different radio network solutions
- Avoid problems *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)
Virtual Radio Network Configuration

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

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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
New business models & relationships

- Separation of
  - infrastructure provider
  - (virtual) network operator

- Decoupled development life cycles
  - long-term
    - infrastructure
    - capacity
  - short- / mid-term
    - (dynamic and flexible)
      - virtual (radio) network
      - functionality

Diagram:

- Infrastructure Owner
- Virtual Network Operator A
- Virtual Network Operator B
- Physical Node
- Configuration of Virtual Nodes
- VRN 1 VRN 2 VRN 3 VRN 4
- Control
- L2
- HL
- c-plane u-plane
- PHY
- RAC (per VRN resource block allocation)
- harmonised resource access
Examples

Wireless Automation Network
- Optimised for large quantity of low-rate data (machine-to-machine) services
- 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

Wireless Automation Network

Mobile Broadband Network
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?