Dynamic Spectrum Allocation
Introduction

- Radio spectrum is allocated with static licensing to a particular radio standard.
- Network operators own their spectrums, which are of fixed size and protected from interference by guard band. They remain solely for the use of the license owner until the license expires.
- This makes simple to design hardware for use at a known frequency band.
- The wireless networks converge (the boundaries between the services offered over different systems slowly disappear) and composite networks emerge.
- The old spectrum allocation and separation will make the resource utilization inefficient.
Dynamic Spectrum Allocation (DSA)

- Most networks are subject to time and regional variations (traffics may vary with time and location) in the degree to which spectrum is utilized.
- The waste of spectrum happens when traffic in one place is low while in another place is high.
- **Objective of Dynamic Spectrum Allocation**: Manage spectrum in a converged radio system and share it among all participating radio networks over space and time, to increase overall the spectrum efficiency.
- **Potential enablers of DSA**
  - Composite networks (allows seamless delivery of services through the most appropriate access network)
  - Reconfigurability
Regulatory Interest in DSA

- Spectrum is a national resource and therefore currently national regulators have the responsibility to ensure economical use of spectrum resources.
- Converged radio networks and services require to simplify the regulatory framework.
- World Radio Conferences (WRC) and some governments start to study the way spectrum is regulated in the next decade.
- Regulatory process is very slow (3G spectrum had to be allocated 10 years ago).
DSA and other related fields

• The related research fields include:
  – Dynamic Channel Allocation (DCA) (The concept of DCA is close to DSA but it considers a single radio network)
  – Frequency assignment (Frequency assignment aims to find the optimal assignment of frequencies in base stations under the constraints of interference and coexistence)
  – Unlicensed spectrum access (open resource – not suitable for multimedia and delay-sensitive applications)
  – Spectrum co-existence (allow different networks to co-exist within the same radio spectrum, i.e. digital and analog TV)
Objectives and Schemes of DSA

- DSA is mainly interested in methods that allow different radio systems with different characteristics (different cell sizes, different services, multicast/broadcast/unicast, etc.) to dynamically share a set of radio resources.
- DSA aims to share the spectrum between the networks at a radio access level (i.e. develop schemes that are between DAC and spectrum coexistence). That is share the available radio resources among different Radio Access Networks (RANs)
- We concentrate on methods that permit two or more networks to share an overall block of spectrum so that spectrum allocations can adapt to either temporal or spatial variations in demand on the networks.
Contiguous DSA

- Only contiguous blocks of spectrum are assigned to different RANs.
- The width of the spectrum block assigned to a RAN varies to allow for changes in demand.
- The RANs can only use the adjacent RANs spectrum resource. If a RAN wishes to increase its spectrum, it will not be able to do so if the spectrally adjacent RAN does not release its spectrum.
- It is a simple way to implement dynamic spectrum allocation but will be inefficient if more than 2 RANs sharing spectrum.
Fragmented DSA

- Spectrum is treated as a single shared block
- Any RAN can be assigned an arbitrary piece of spectrum anywhere in this block
- It is advantageous if more than two RANs are sharing the spectrum
- It is more difficult to control the interference. More guard bands are required
Temporal DSA Operation

- Temporal DSA tracks the traffic load change and makes corresponding spectrum allocation
- Typical steps of temporal DSA
  - Step 1. Periodic triggering of DSA algorithm (time scales could be on the order of tens of minutes to several hours depending on traffic)
  - Step 2. Management of the traffic on the carriers
  - Step 3. Prediction of the loads on the networks (DSA runs periodically and not on a call-by-call basis. Therefore traffic may change during the DSA period, and thus prediction of expected traffic is required – based on histories of past traffic, time-series estimation algorithms).
  - Step 4. Allocation decision (issues to be considered: performance, and fairness of DSA schemes)
Spatial DSA

• We wish to adapt the spectrum allocation to the regional demands on the networks for a given time.
• The area must be divided into DSA areas, which are regions with relatively constant traffic demands.
• Spatial DSA allocates spectrum to RNAs according to the traffic demands in each DSA area.
• Coordination of the spectrum allocation between adjacent DSA areas is required to avoid interference.
Equipment Requirement

- Multiband and integrated narrow/wideband antennas with miniaturization constraints for small-sized devices
- Flexible frequency carrier tuning
- Variable duplex distance between forward and reverse links for frequency-division duplex based systems
- Flexible receiver signal filtering
Reference