Dynamic Spectrum Management for Multi-Radio Environments

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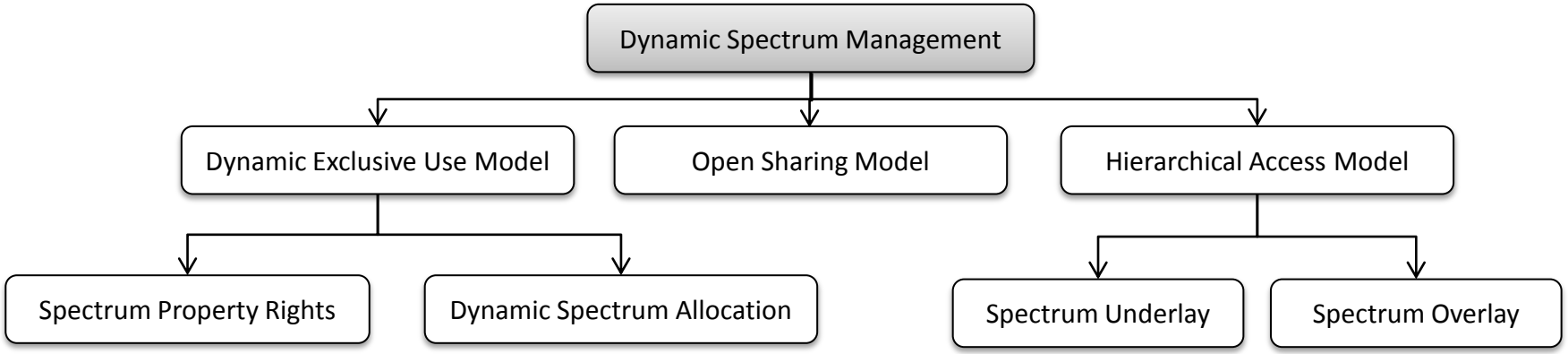
Motivation

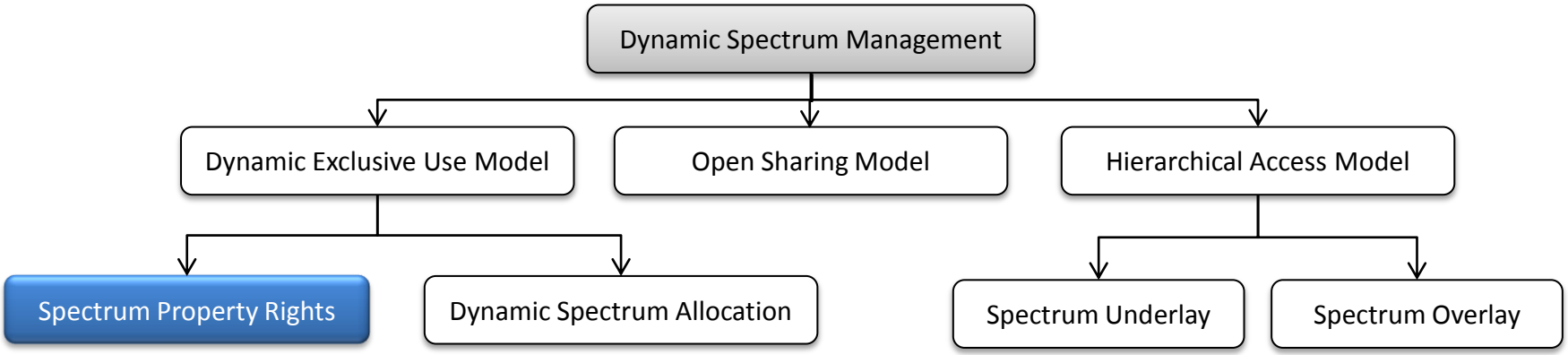
- Current wireless technologies are facing limited resources in the frequency domain.
- Today, spectrum is allocated statically due to regulatory constraints.
- Dynamic Spectrum Management (DSM) can increase system performance by managing spectrum in a flexible way.

DSM Concepts

- Different approaches how to achieve Dynamic Spectrum Access (DSM):

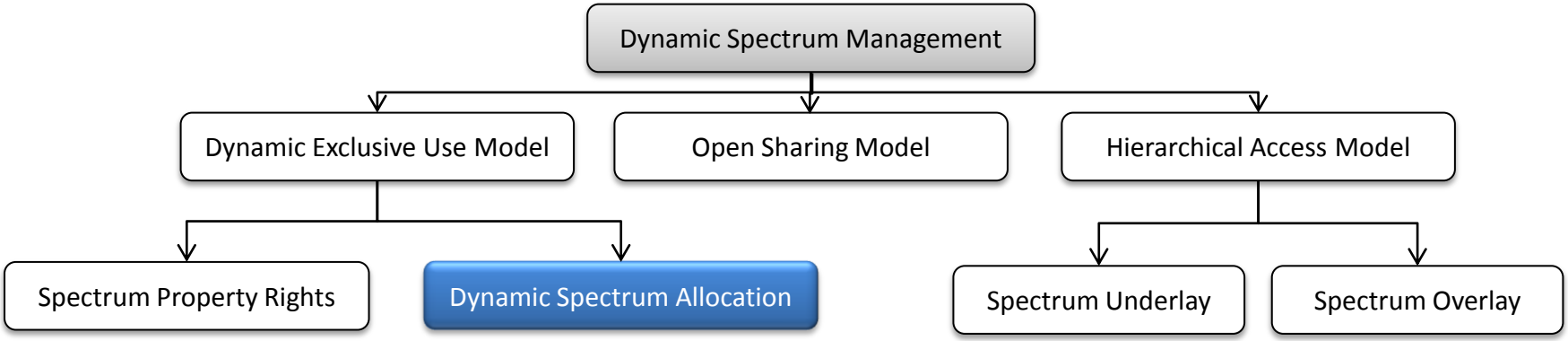


DSM Concepts



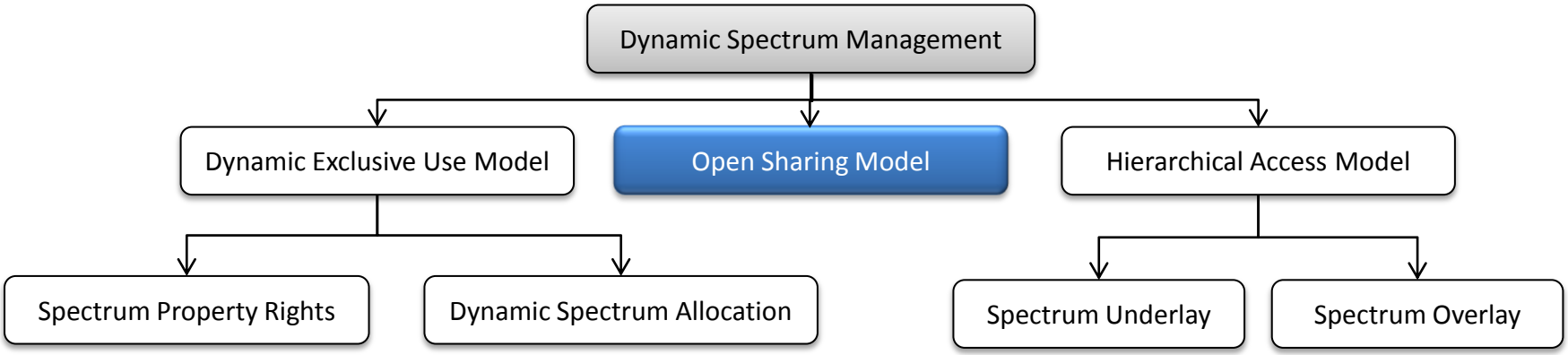
- Allow selling and trading of spectrum.
- Freely choose technology.

DSM Concepts



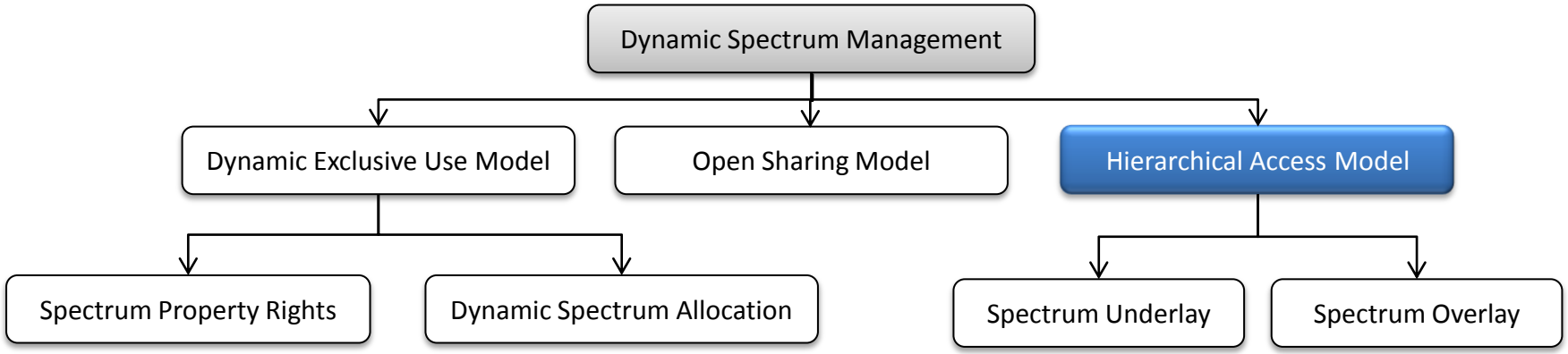
- Dynamic spectrum assignment to different services.
- Exploit spatial and temporal traffic variations.

DSM Concepts



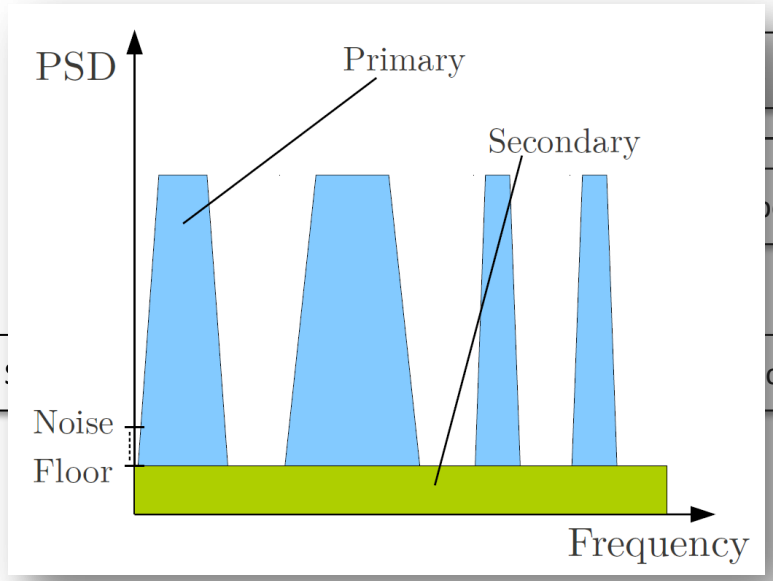
- Open sharing among peer users.

DSM Concepts



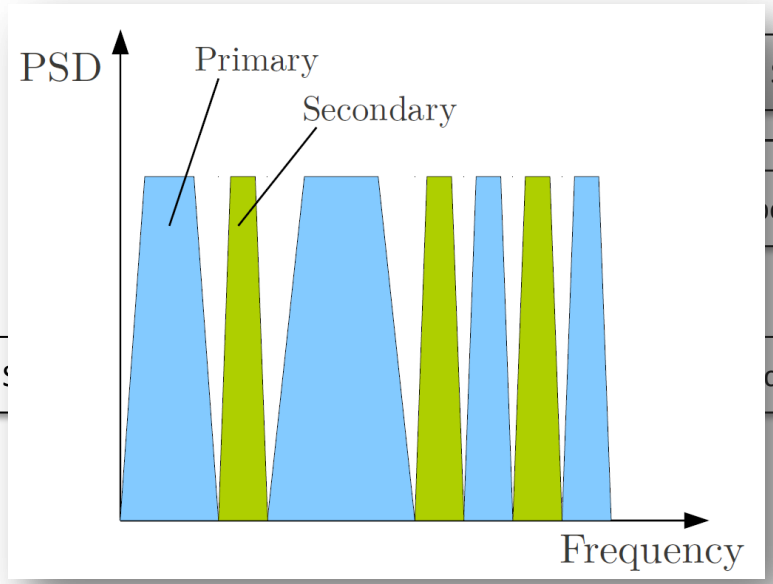
- Hierarchical Access with primary and secondary users.

DSM Concepts



- Constrained transmission power.
- Operate below primary users noise floor (UWB).

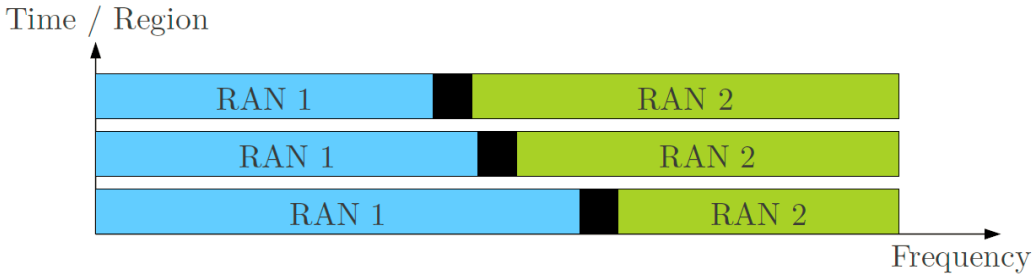
DSM Concepts



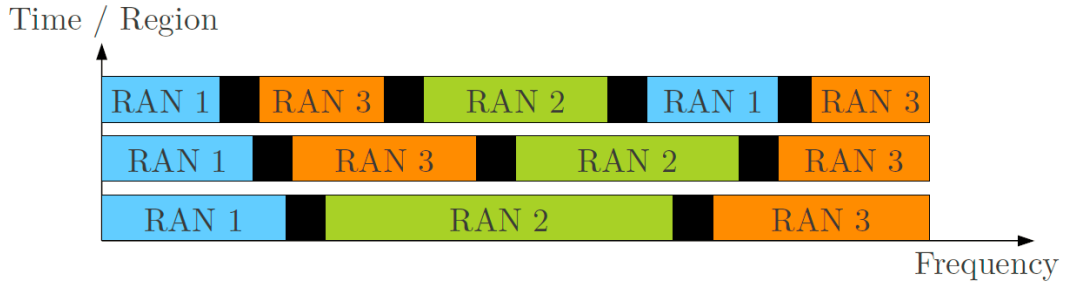
- Constraint on where and when to transmit.
- Exploit spatial and temporal white spaces.

Dynamic Spectrum Allocation

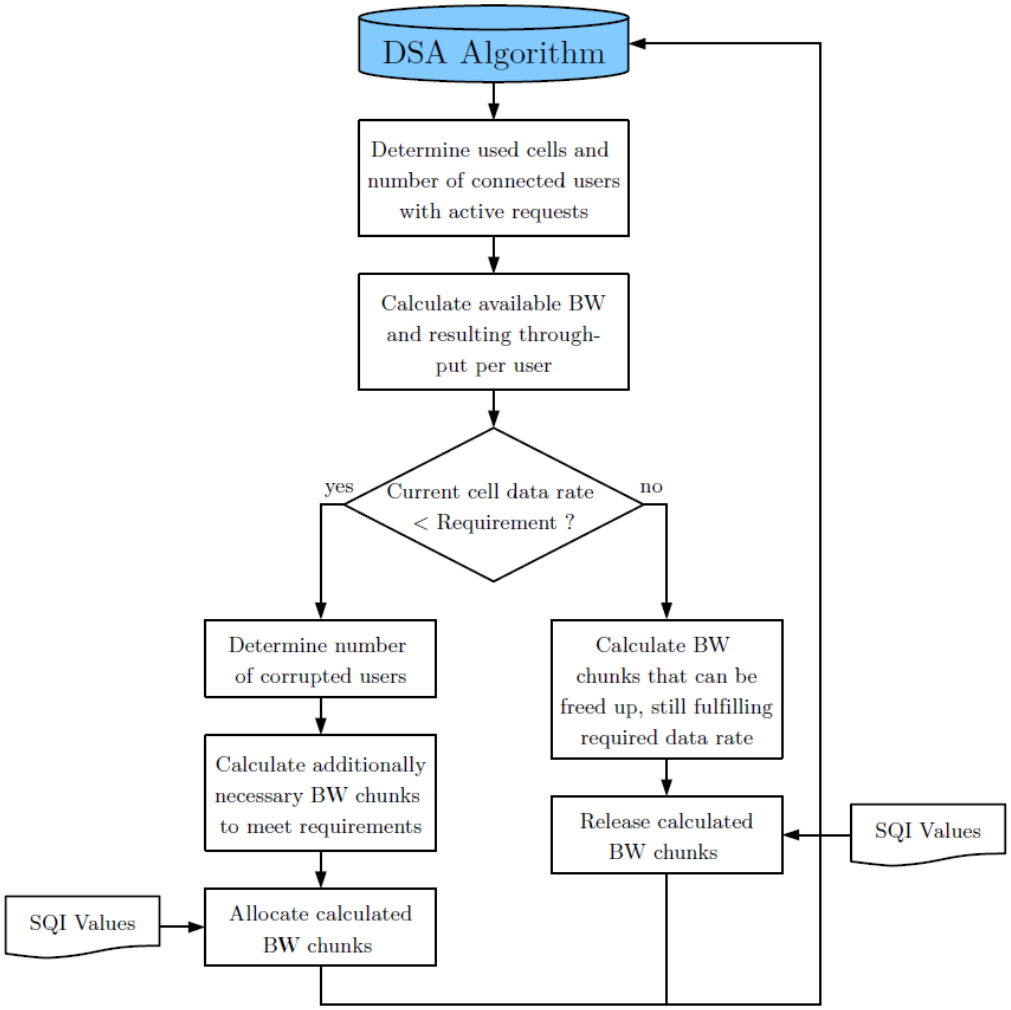
- Contiguous DSA: Contiguous blocks of spectrum are allocated to different RANs.



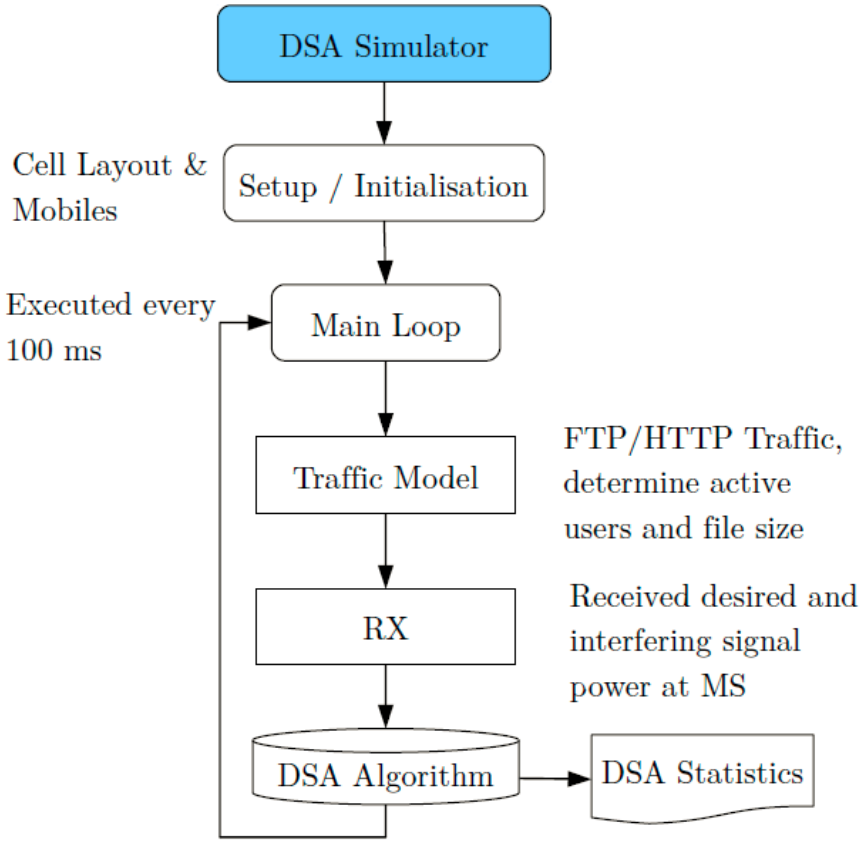
- Fragmented DSA: Any arbitrary piece of spectrum can be allocated.



DSA Algorithm

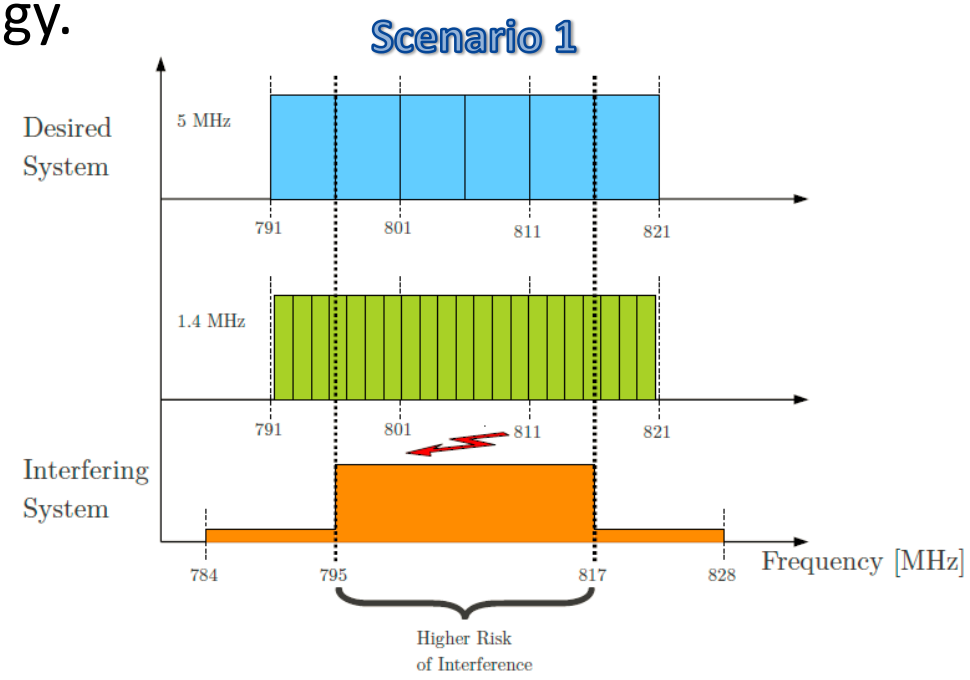


Simulator Model

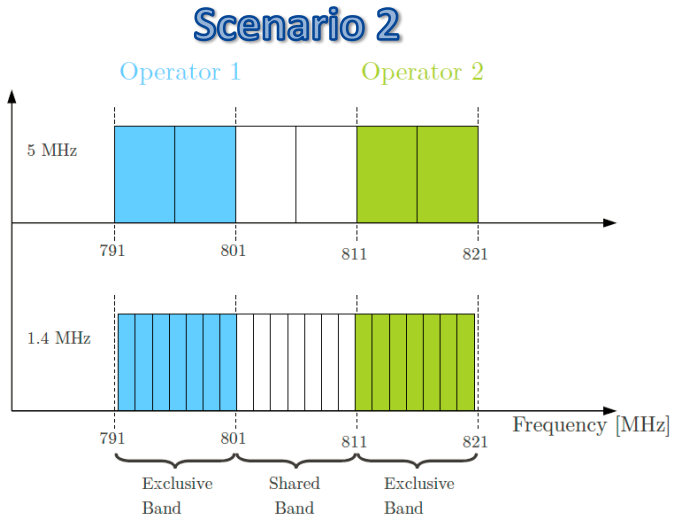


Simulator Model

- Spectrum Allocation based on predefined bandwidth chunks with size of 1.4 and 5 MHz.
- Calculation of interference events based on SEAMCAT methodology.



Simulator Model



- Quality of bandwidth chunks can be assessed by the introduced Spectrum Quality Indicator (SQI):

$$SQI_i = \frac{N_{i,not\_interfered}}{N_{i,used}} \cdot 100 = \left(1 - \frac{N_{i,interfered}}{N_{i,used}}\right) \cdot 100,$$

- Global and position dependent SQI values are considered to avoid interference.

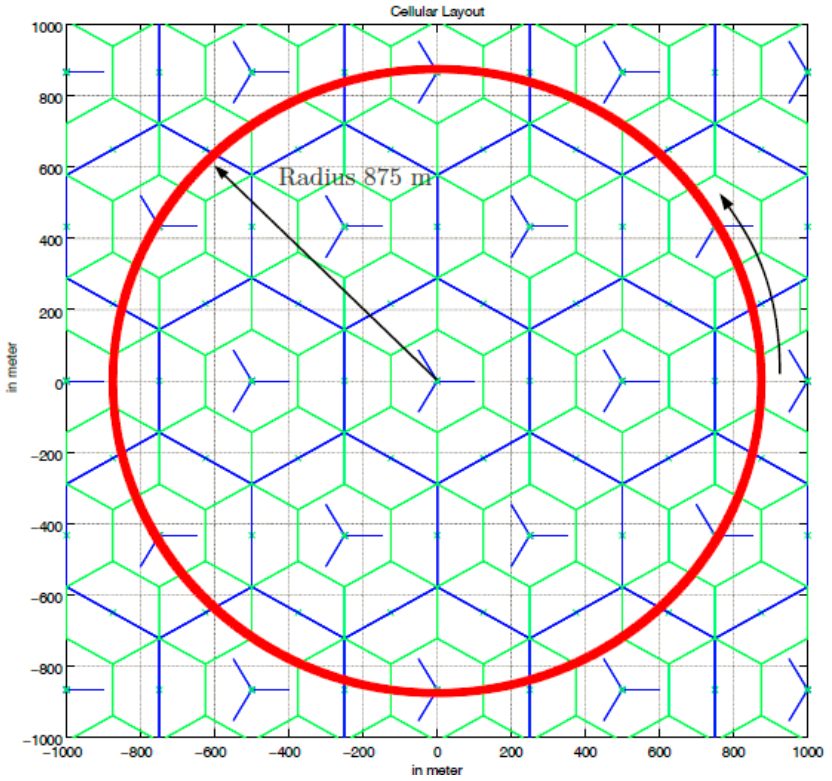
Simulator Model

- Parameters

	RAN LTE	RAN WLAN
Wanted Link	x	
Interfering Link		x
Simulation Interval	100 ms	100 ms
UE Movement	5 Users / Circle 14 Users / Circle r = 875 m v = 22 km/h	
SQI Consideration	None Global Position Dep. (100m)	
Traffic Models	HTTP FTP Full Buffer	Full Buffer
Channel bandwidth	10 MHz	22 MHz
Cell layout	hexagonal	hexagonal
Site-to-site distance	500 m	250 m
Antenna pattern	hex sectorized, 70°	omnidirectional
Hor. Ant. Diagram	3GPP TR 36.942	none
Vert. Ant. Diagram	3GPP TR 36.814	none
Tx Power	43 dBm	30 dBm
Antenna Gain	18 dBi	12 dBi
Antenna Height	24.5 m	15 m
Downtilt	6°	none

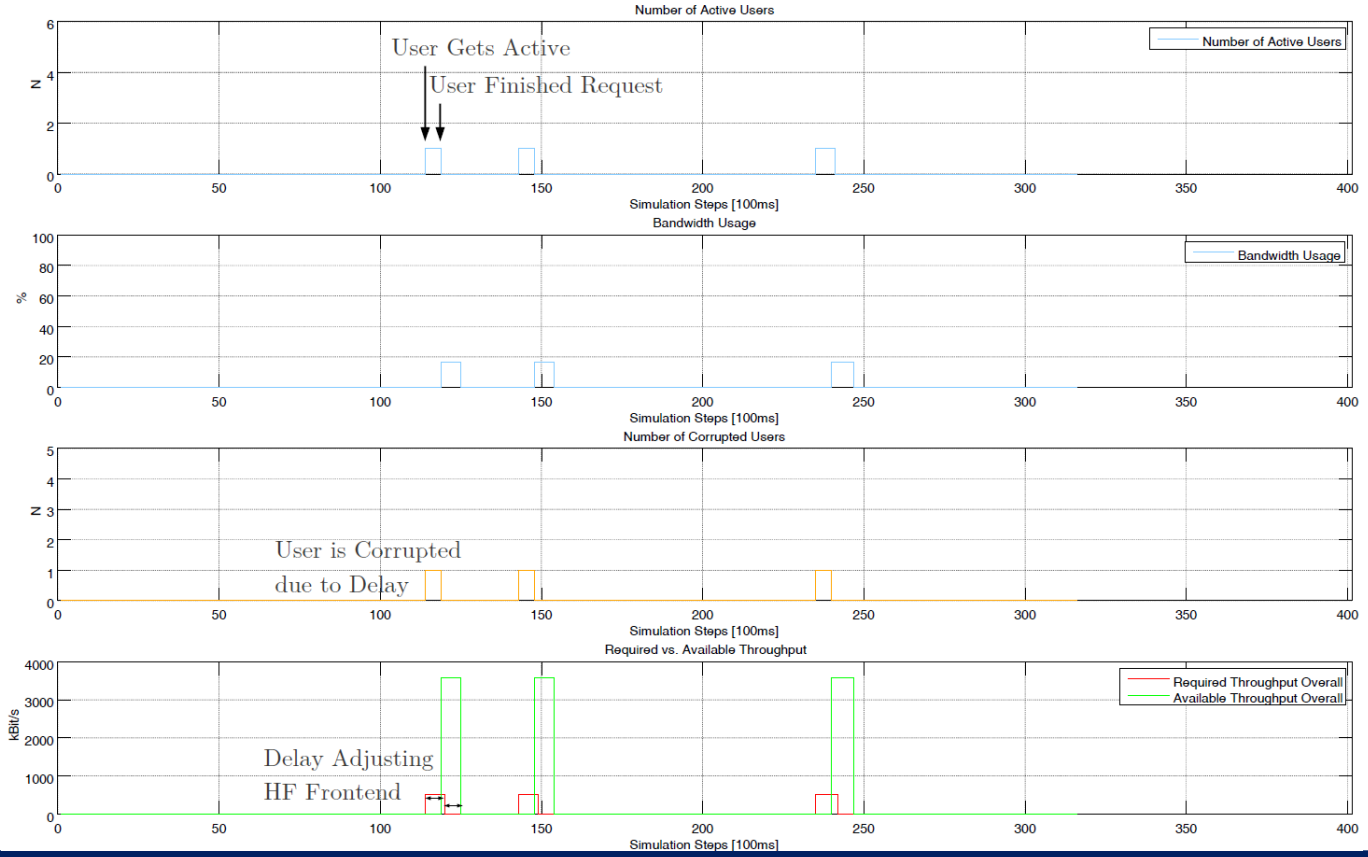
Desired RAN LTE

Interfering RAN WLAN



Simulator Model

- Exemplary temporal graph of DSA algorithm:



Analysis of the Results

- Assess benefit from operator point of view with success rate of bandwidth (BW) allocations:

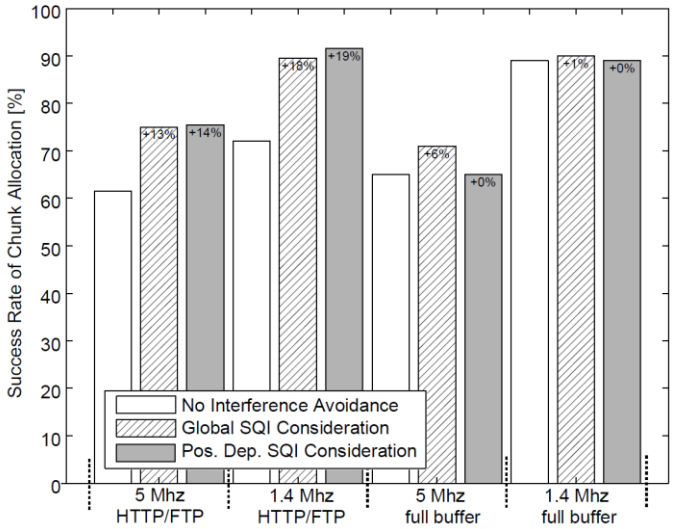
$$Success\_rate_{BW\_allocation} = 100 \cdot \left(1 - \frac{N_{Chunk\_interfered}}{N_{Chunk\_used}}\right),$$

- And by measuring the user satisfaction:

$$User\_Satisfaction = 100 \cdot \left(1 - \frac{N_{data\_rate\_too\_low}}{N_{useractive}}\right)$$

Analysis of the Results

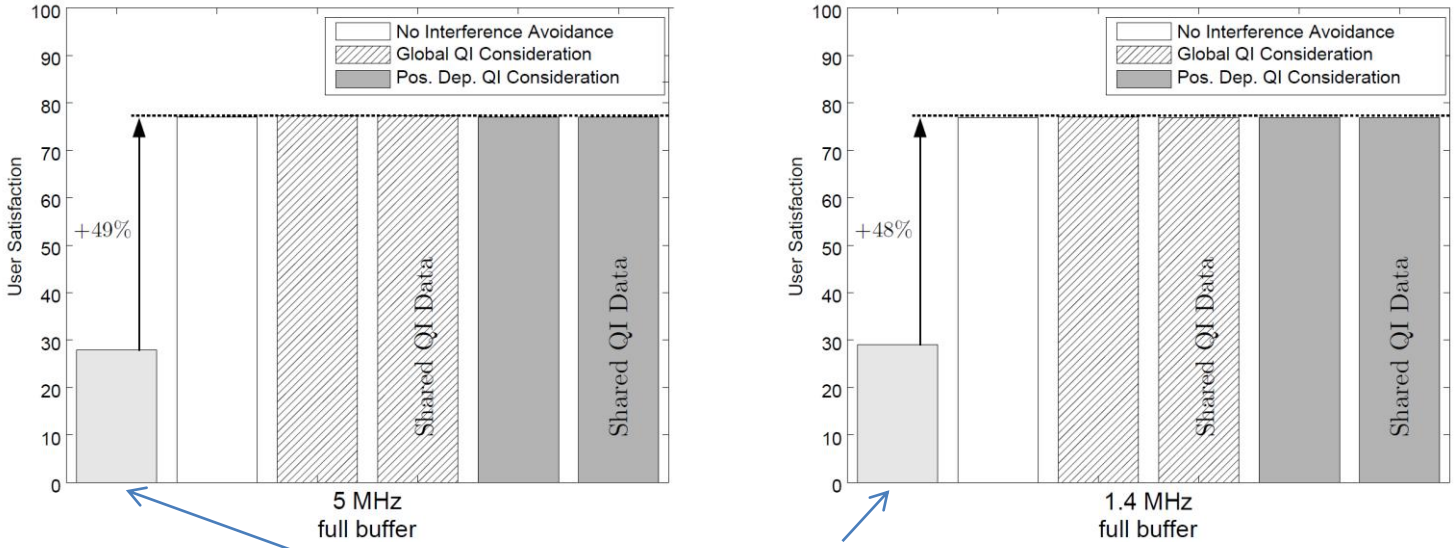
- Success rate of chunk allocation for traffic model (HTTP/FTP) scenarios:



- Significant gains through interference avoidance approaches (based on SQI values).

Analysis of the Results

- User satisfaction for full buffer and 25% base load scenarios:



- Significant gain with shared band usage.
- Impact of SQI consideration is neglectable.

Conclusion

- A basic temporal DSA algorithm was developed and introduced.
- The interference avoidance techniques based on SQI values showed respectable gain for traffic model scenarios.
- The usage of a shared band results in a significant gain for user experience.