Dynamic Interference Coordination

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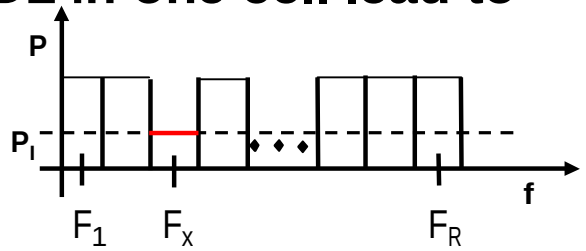
Interference Coordination — Motivation

Basic Idea:

- **Interference in an orthogonal scheme (OFDM) is predictable and avoidable.**
- **Power restrictions on frequency blocks in DL in one cell lead to <u>improved SIR</u> as seen in a neighbor cell.**



- **Mobiles are frequency selective (adaptively) scheduled on these clean frequencies depending on the neighborhood. This improves <u>cell edge throughput</u>**

<u>Similar solution for the uplink:</u>

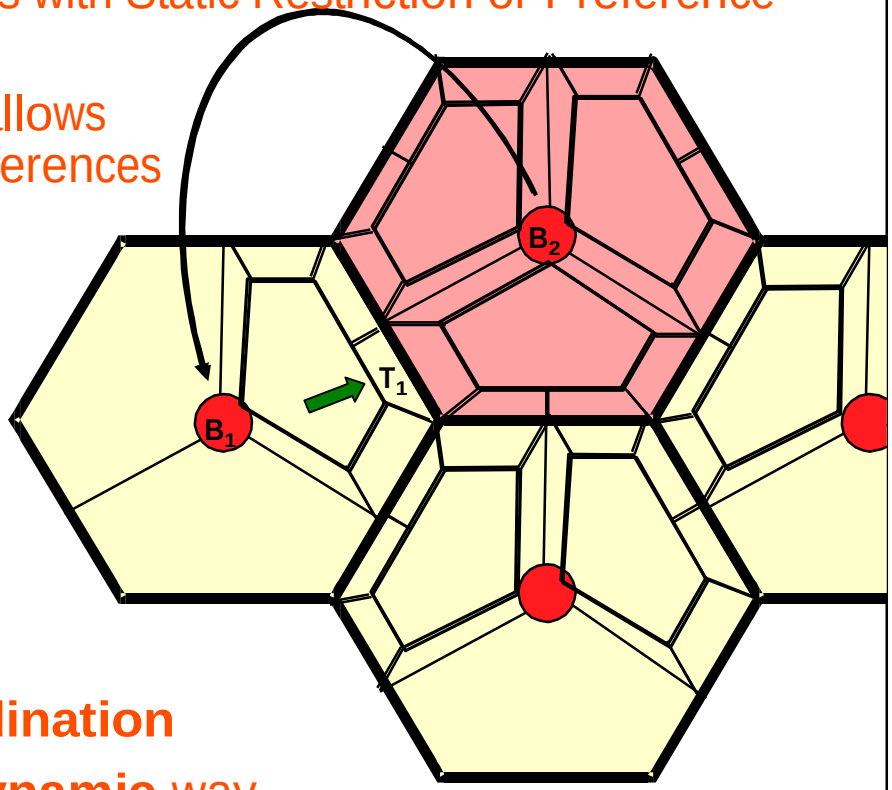
- **Restrictions on frequency blocks in downlink shape the power (interference) spectrum of a sector in DL**
- **Preferences on frequency blocks used by Mobile in uplink shape the interference spectrum of a sector in UL**

Interference Coordination — Strategies

Interference Coordination Restrictions or Preferences

Static Interference Coordination works with Static Restriction or Preference Distribution

Dynamic Interference Coordination allows dynamic changing restrictions or preferences based on cell loads or geometrically changing user distribution.



=> Dynamic Interference Coordination

Assignment on demand basis in a **dynamic** way, enabling the network to adapt to changing data rate requirements in the cells in a self-optimising way.

Inter-sector resource distribution

Signaling:

- Resources are defined as frequency patterns composed from multiple frequency blocks as appropriate for UL and DL. (Diverse pattern allow diverse allocations for VoIP)
- For dynamic restriction or preference setting the number of the frequency pattern (frequency subset) and one scalar value (attenuation/boost) has to be signaled to a neighbor base station

Static and dynamic setting:

- Static Interference Coordination setting can define baseline restrictions (or preferences) based on cell planning
- Dynamic Interference Coordination comes on top of this predefined restrictions

=> base station to base station (backhaul) communication is reduced to amount necessary for cell load and mobile station concentration balancing.

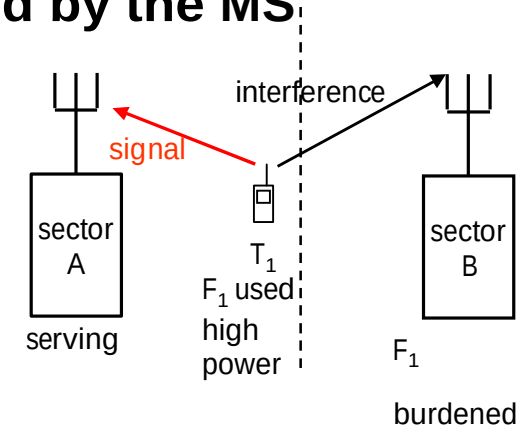
Restriction Setting Meaning in DL and UL

Definition for Downlink:

- **Restriction on F_i in neighbor sector B means => F_i is preferred for Mobile station T1 located in neighborhood to B**
- **If there shall be more throughput for a MS in neighbourhood to B more frequencies F_k are requested to be restricted.**

Dual formulation can be found for Uplink:

- **Mobile station preferred frequencies also defined by the MS location**
- **Restriction on F_i in neighbour sector B means =>B accepts an interference burden on F_i F_i is preferred for Mobile station T1 located in neighbourhood to B, Mobile station can transmit with high power on F_i.**



- **If there shall be more throughput for a MS in neighborhood to B more frequencies F_k are requested to be burdened (restricted) also. No other cells have to be asked. Further other sector MS use F_k also.**

Decision over Resource setting

Task of Dynamic Interference Coordination:

- **Lightly loaded cells can give support to highly loaded cells or cells with local high concentration of MSs at the cell border.**
- **Mixture of real-time or guaranteed bit-rate traffic and best effort traffic.**
  - **Best effort traffic can be reduced in own cell in order to support large guaranteed bit-rate traffic in highly loaded neighbor cell**
- **Above evaluation must be**
  - **Traffic load based**
  - **Mobile station locations based**

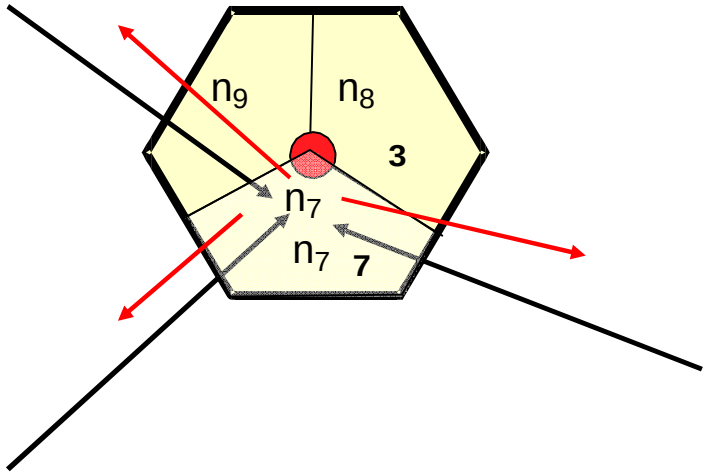
  => Coordination must start with a request from the loaded cells

=> Overloaded cells shall send mute requests or requests to accept interference burden to their neighbor cells over an interface (slow time-scale)

Request – Grant Mechanism

Distributed Radio Resource Management:

- **Sending of requests and responding with grants**

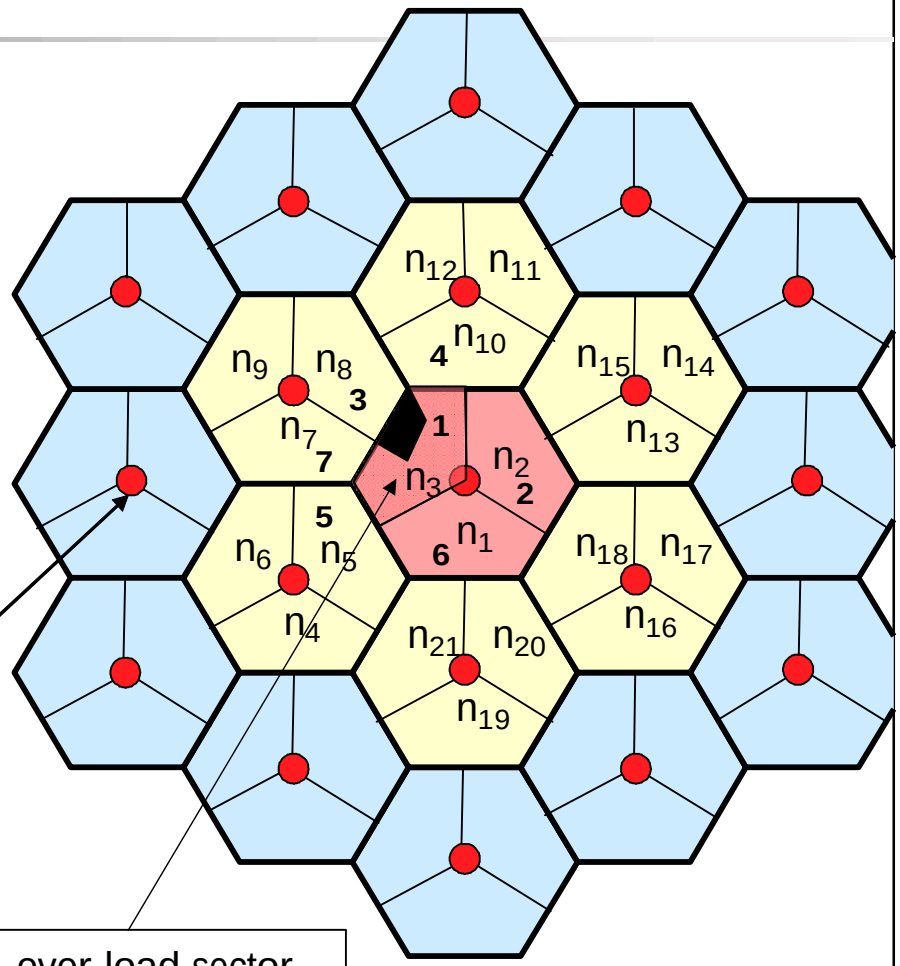


- **Only sector n7 scheduler can decide whether to accept these requests or not. Decision will be based on own traffic load and usefulness of frequencies for its own traffic.**
- **The requested base stations should afterwards give grants and inform requesting base stations**

System simulation

Description of setting:

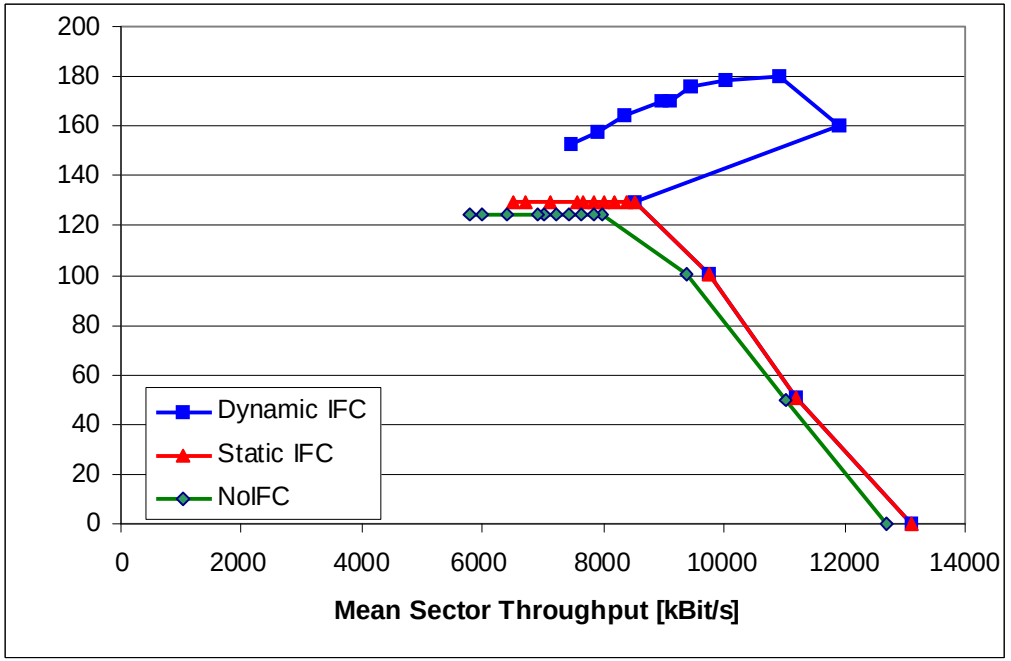
- In all normal loaded sectors about 10 MS are distributed in average
- In one overloaded sector n3 a number of 30 MS are distributed across the border area (black quad) to one neighbor sector.
- Local request /grant exchange Simple negotiation algorithm
- Limited communication need
- Scheduler tries to achieve minimum terminal bit-rate before distributing bandwidth more opportunistic



Results

5%ile user throughput and sector throughput for overloaded

- **Terminal bit-rate of 50, 100 kbit/s etc. are stepped through**
- **As long as in overloaded sector minimum terminal bit-rate can be achieved, the sector is not asking for help => red and blue curves are identical**



- **Asking for higher bit-rate => Static IFC (red) saturates**
- **In case of Dynamic IFC sector n3 asks for help from neighboring sectors. It gets granted resources ->improves SIR for the MS =>blue curve sector throughput increases by 40% and 5%ile increases by 23%!**

Results (continued)

- **In next step for Dynamic IFC the 5%ile can be increased further to 180kbit/s while sector throughput decreases again**
- **For even higher terminal bit-rates neighbor sectors do not provide help that often any more, and 5%ile and sector throughput decrease again.**
- **Algorithm can be refined to get smoother curve**

Neighbor sectors can provide large improvement

Most important increased 5%ile

Serving more Terminals with Guaranteed Bit-rate Traffic

By Dynamic Interference Coordination now 30 Mobile Stations with 180kbit/s without call drop can be served, while without Dynamic Coordination only 22 terminals with 180kbit/s are served

Dynamic IFC can absorb peaks in cell load and user distribution -> higher cell edge rates and Quality of service

Conclusion

Principles of Dynamic Interference Coordination investigated

Subject of Coordination are Frequency pattern (subsets)
Dynamic Coordination should be build on top of Static (cell planning) to reduce backhaul traffic

Definition of resource setting, dual formulation for DL and UL

Methodology of Resource Management => Mute requests (burden requests) and Grants in response

Distributed Decision process can be implemented =>Proposal to include Framework in Standardization Process for Dynamic IFC
Large Potential shown by first System Simulation results with low inter-cell communication

Dynamic IFC leads to higher cell edge rate and QoS