lec 2.05: Wireless local area networks: HetNet and small cell deployments, mmWave

Some ways to improve capacity

- Improve the radio link efficiency (more bps over the same link)
- Get more spectrum
- Topology, meaning more nodes in the wireless network

Cell densification is a way of improving access to the network. More cells can ensure that data is served to the user in a timely manner

A homogenous network in terms cell distribution would be one where all users in a cell limit are only connected to that cell. There is a strict boundary. Users at the cell edge could suffer.

A heterogeneous network in terms of cell distribution is one where one could have small-cell base stations (femto/pico cells) which can connect to users in adjacent cells i.e being in the confines of one cell does not mean you connect to the base station of that cell as it is possible for small-cell base stations from adjacent cells to serve you. This improves the connection for users at the cell edge.

Heterogeneous networks:

- improve coverage for users at the edge of a cell
- Higher throughput

Throughput is upper bounded and so adding more femto/pico cells (the little guys) does not necessarily mean greater throughput. This could be due to the number of users in a given cell boundary. That number is limited.

Interference

Nodes all share the same frequency bandwidth and use OFDMA

There can be inter cell interference where a femto interferes with a macro cell and vice versa i.e they're both trying to connect to the same user -> Macro to LPN interference

A PAN is a network of personal devices, think your phone and its peripherals such as a smart watch. Here one device could assume the role of the master device/AP and the other personal devices communicate with this device to perform any functions or external network actions. Bluetooth is also a PAN network technology

Issues

- performance degradation due to inter-cell interference. Reducing the Cell-Edge TH and Network TH

- Complex planning of radio resources
  - Inter-cell signalling overhead
  - Need for self-organization

Spectrum

Reuse is referring the cells using the same frequency. They can do this is they are sufficiently far apart or if their coordination is ell done.

Reuse one to one would mean that the entire bandwidth is being used and inter cell interference can become an issue at the cell edge.

Reuse 3:1 means that the macro base station uses one third of the bandwidth and the pico stations use all the bandwidth

Orthogonal assignment means the macro-cells use one third of the same frequency and the pico cells are given the remaining two thirds.

Propagation model

the propagation model matters. Looking at cell density from a throughput perspective may promote increasing density whereas from an energy efficiency perspective it may make no sense.

mmWave

micro-metre seems to be up to 3GHz and from 3GHz onwards (maybe up to 300GHz) is the millimetre-wave band

Huge amount of available spectrum in the millimeter wave bands

mmWave is used in:

- VANET
- LAN
- PAN
- Backhaul in cellular networks

From what I can tell Backhauling is referring to getting the data to a point in the network where it can be distributed.

Blockage is a bug impairment for millimeter wave. LOS is needed for ideal communication

Implications:

- Need a high base station density
- Indoor users don't get coverage
- Blockages reduce the impact of interference
- Very high data rates for mmWave
- Mobility may be a challenge

- Shared license access possible to reduce costs, give carriers access to more spectrum

Blockage: Same as shadowing but the extreme case. The signal cannot propagate due to losing line of sight.

- blockage due to people
- blockage due to buildings
- hand blocking

To fix blockage we can use a high density of base station

Massive MIMO used to remedy blockage. Using a lot of antennas to provide for the most users

Key Points

- Coverage can be acceptable with right system configuration
- Strong candidate for higher per-link data rates
- Hardware can leverage insights from 60GHz LAN and PAN
- Highly directional antennas may radically change system design
- Mobility support may be challenging

Acronyms

- HetNet: Heterogenous Network
- PAN: Personal Area Network'
- LOS: Line Of Sight
- NLOS: Non-Line Of Sight
- MU: Multi-User
- VANET: Vehicular Ad-hoc Network
- LMDS: Local Multi-point Distribution Service
- UE: User Equipment
- TH: throughput