5G Networks and High-Efficiency Device Positioning: Enabling Techniques, Demonstration and Verticals

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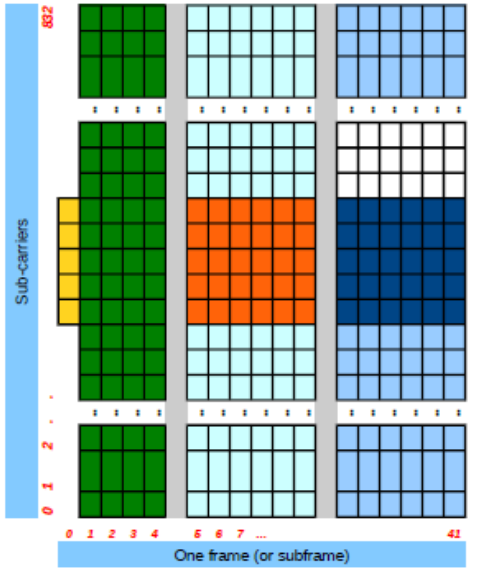
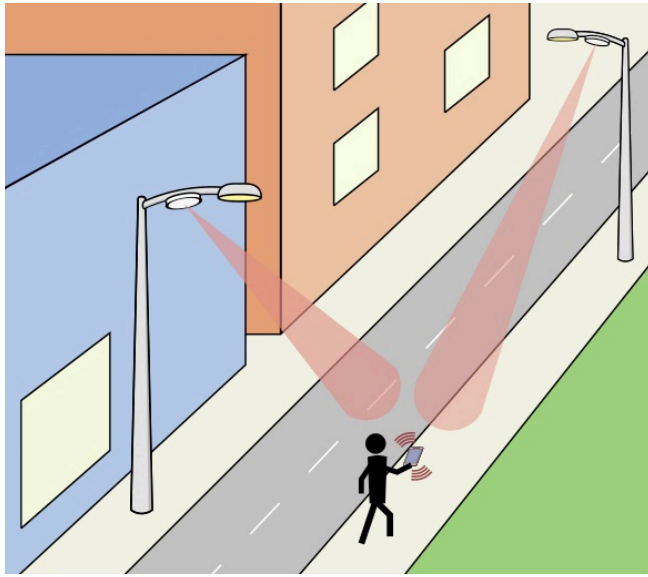
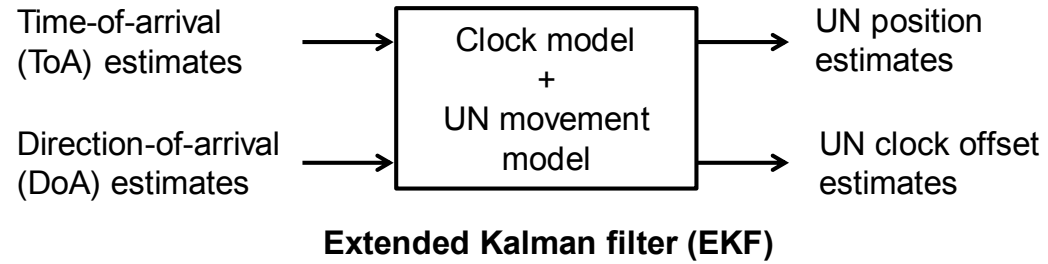
- Network densification and high bandwidth allows accurate UE positioning
  - Use the expensive 5G investment to get positioning “for free”
- 1-2 orders of magnitude better dyamic accuracy than GPS, with 1-2 orders of magnitude lower power consumption in the UE
- Advantages
  - Proactive mobility management and RRM in 5G radio network (*, UE tracking and movement prediction)*
  - Self-driving cars, robots benefit from accurate position info
  - Indoor positioning
  - Augmented reality
  - IoT device positioning,logistics..
- Implementation based on
  - TDD MU-MIMO system
  - Data fusion over multiple measurement points
  - ToA/TDoA & DoA measurements based on UL beacons (~SRS)



C-UDN Frame structrue



C-UDN concept



Extended Kalman filter (EKF)

Joint User Node Positioning and Clock Offset Estimation in 5G Ultra-Dense Networks: http://www.tut.fi/5G/positioning/media.html

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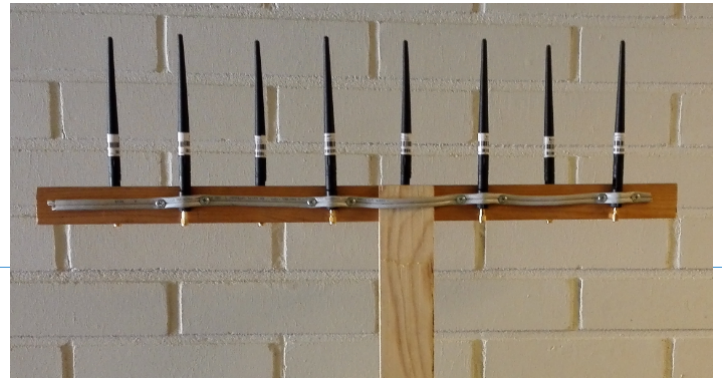
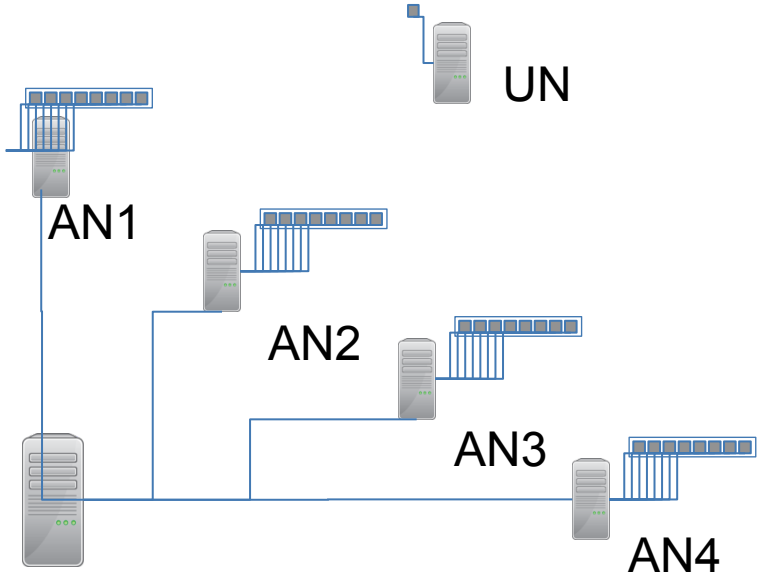
- C-UDN test-bed
  - 4 Access Node (AN) sites
  - 4 – 8 antennas per AN
    - Linux server operates as BS
  - 1 antenna in mobile
  - Constructed of USRP + PC
    - Comm. stack in C++
    - TDD implemented by using USRP switch between Tx - Rx chains (not circulator)
  - Transmission
    - Frequency license 3.41 – 3.43 GHz
    - Sampling rate 15.36 MHz
    - 5 micro sec OFDM symbol length
      - easy to test also for different values



8 antenna array



C-UDN test-bed architecture

AN & UN

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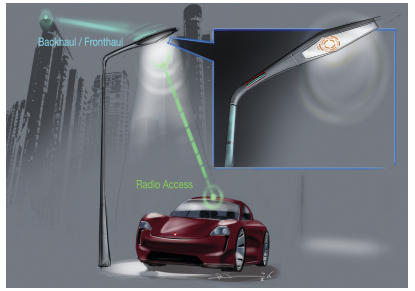
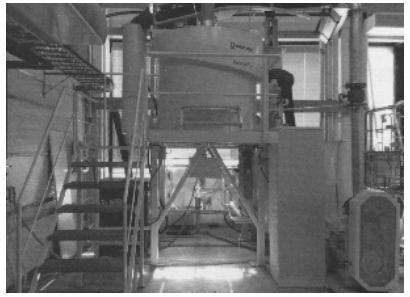
- Testing environment for verticals
  - Otaniemi – sub-urban area
  - Ruoholahti – urban area
- Verticals
  - TA7: 5G for Future MTC solutions:
    - Device localization, energy efficiency through UE beacon based signaling
  - TA20: Open Portfolio Target Action
    - Verticals benefitting from accurate localization and low latency
      - V2X, Factories of the future, e-health,…

Example verticals



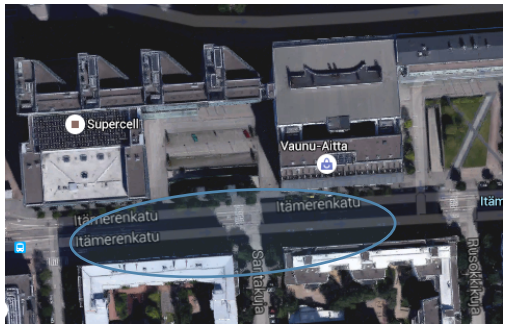
V2X



Facories of the future:
Aalto Industrial Internet Campus
http://aiic.aalto.fi/en/

Test sites

Otaniemi test-site (sub-urban / industrial)

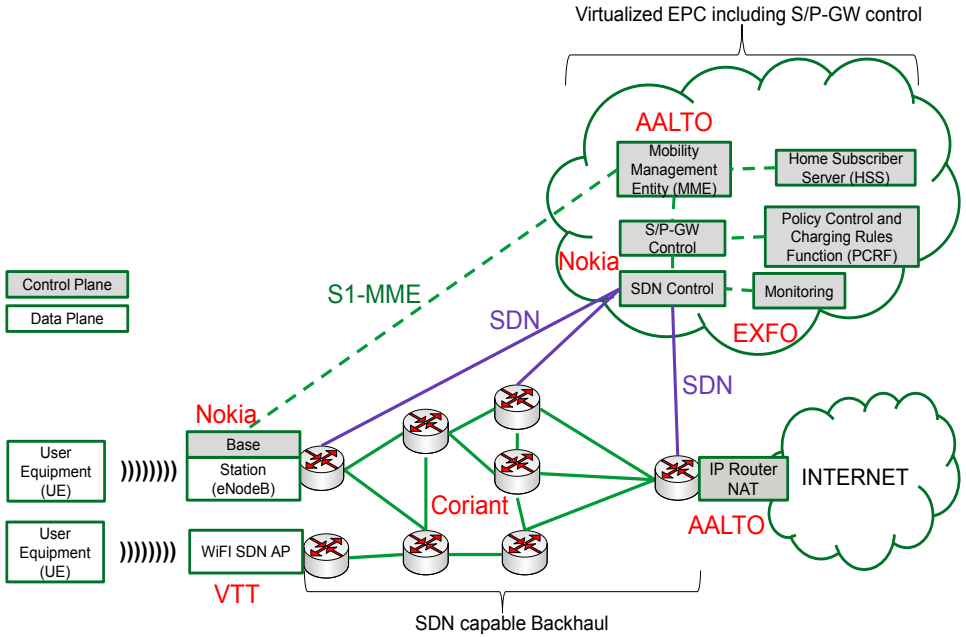


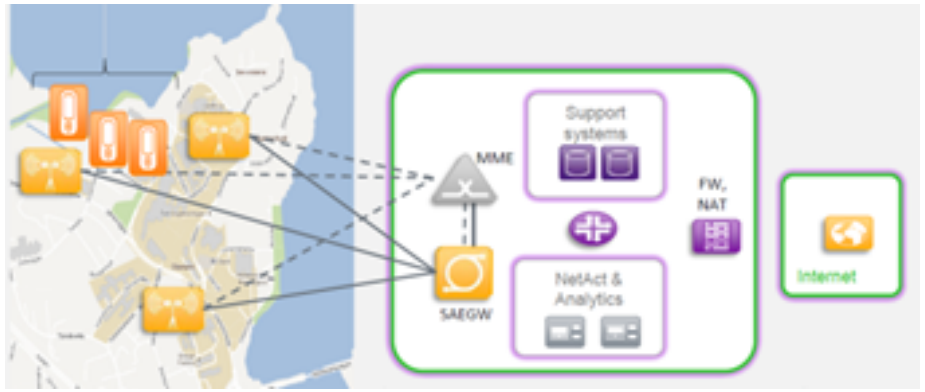
Ruoholahti test-site (urban)

Take-5 testbed in Espoo, Finland – part of 5GTNF

http://5gtnf.fi/
http://take-5g.org/

- Multidisciplinary and open research platform for investigation and experimental evaluation of innovative ideas in networking and services of 5G.
- A common shared testbed for testing and validation of 5G network functions:
  - Network virtualization and cloud technologies
    - Virtualized EPC with network slicing
  - Novel RAN solutions & virtualization
    - **Continuous Ultra Dense Network (C-UDN)**
    - Cloud-RAN (LTE)
    - NB-IOT
  - Services that require network responsiveness and end user experience.
  - Cybersecurity, end to end security and trust in 5G





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