Centre for
White Space
Communications

‘Super Wi-Fi’

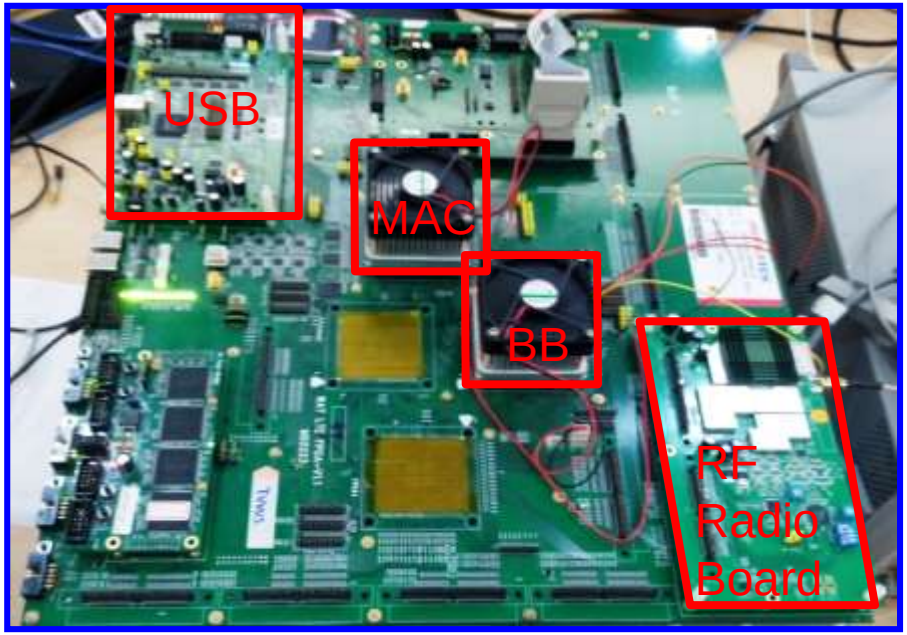
In-Home TVWS Measurements Using IEEE 802.11af

Contents

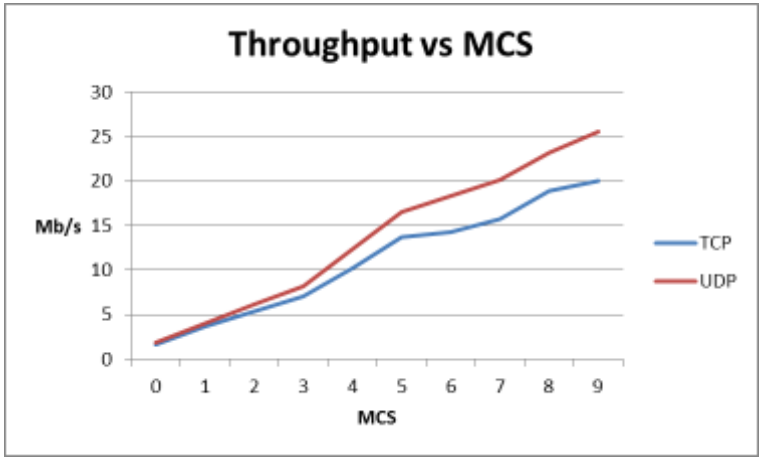
- Background – 802.11af and motivation for project
- MediaTek/6H tri-band Wi-Fi radios
- Testing in Sky homes
- Results and Conclusions

IEEE 802.11af

- ‘Tri-band’ Wi-Fi radio developed by MediaTek and 6Harmonics:
  - IEEE 802.11af operating in the TVWS band (470-790 MHz);
  - IEEE 802.11n operating in the 2.4 GHz band;
  - IEEE 802.11n operating in the 5 GHz band.



- 802.11af capable of operating in 6, 7, or 8 MHz bandwidth.

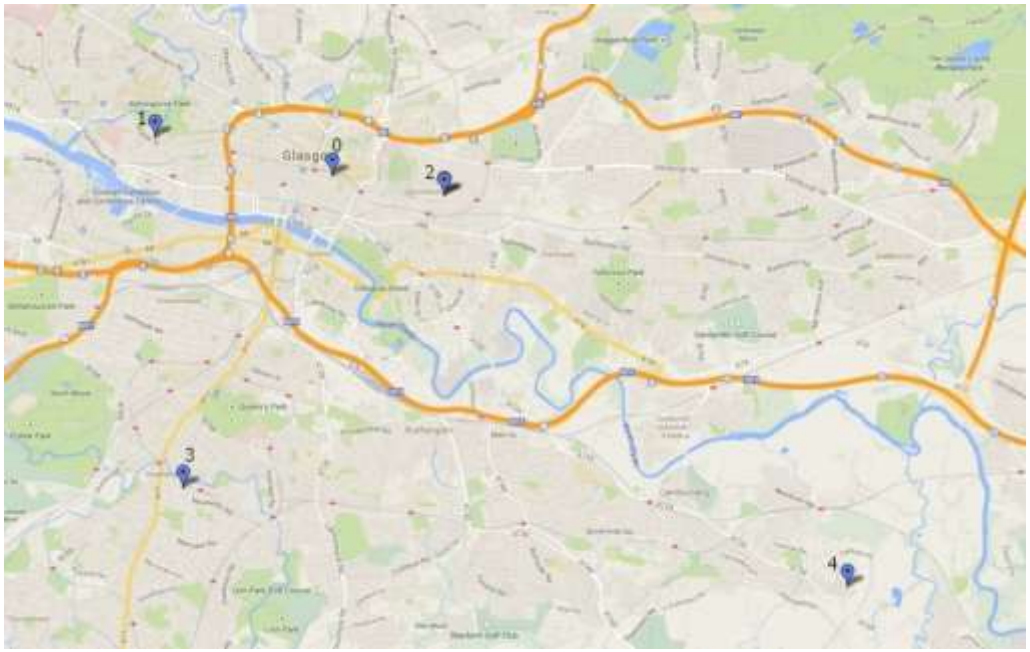


MEDIATEK

6Harmonics

In-Home Measurements

- Aim: To measure 802.11af performance in a small number of homes and compare with 802.11n in 2.4 GHz and in 5 GHz.
- Motivation: 802.11af has the potential to improve range and coverage within homes, and therefore has strong relevance for ISPs such as Sky.
- Four homes selected:



Measurements/Tests:

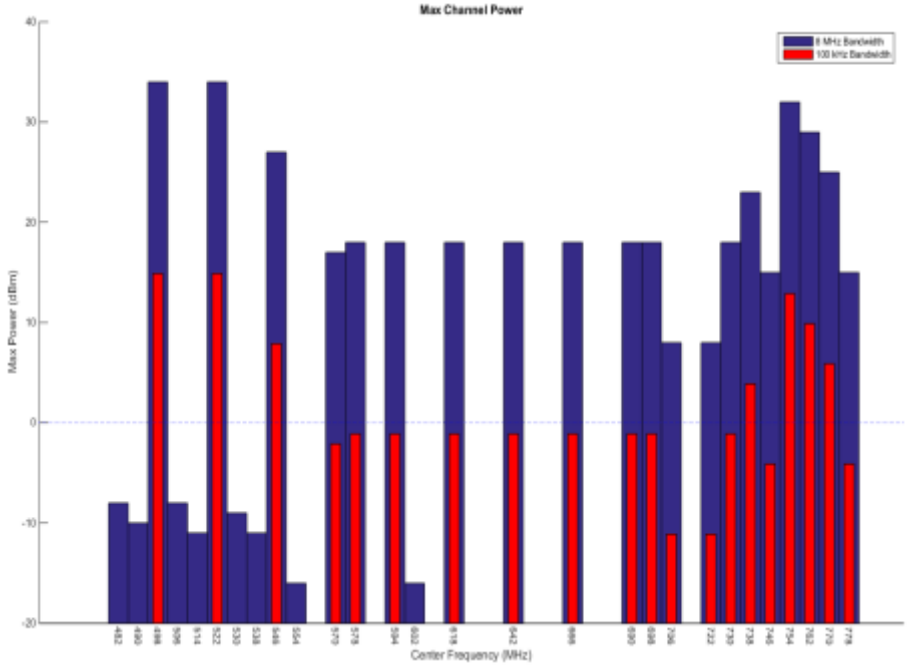
- RF signal coverage
- Data throughput rates
- Full HD video streaming

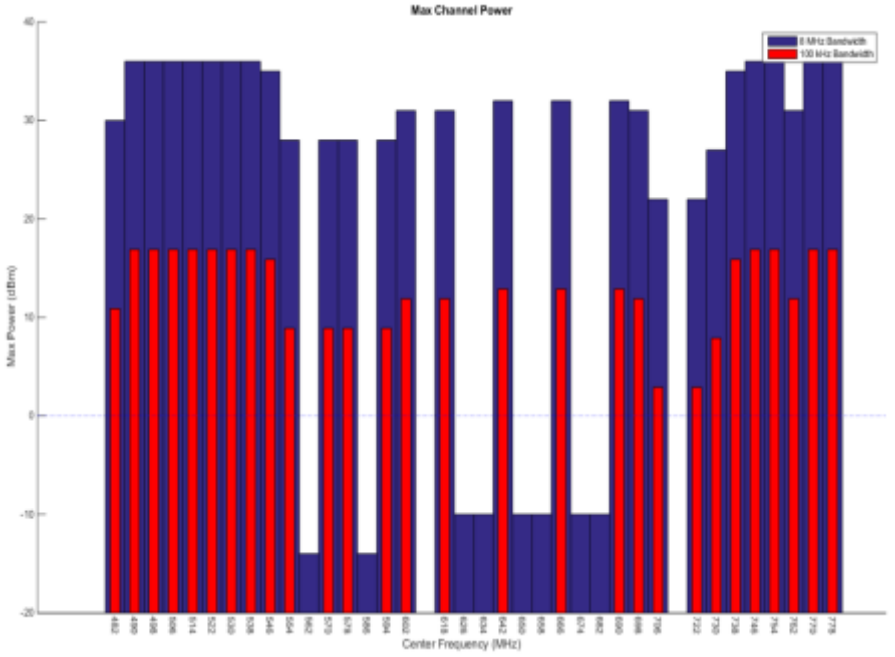
The Four Homes

- Two 1st floor tenement flats of ‘older’ construction:
  - Thick sandstone outer walls; brick internal walls
- A large, 3-storey house of ‘older’ construction:
  - Thick sandstone outer walls (60cm thick in some places); brick internal walls
- A modern detached villa:
  - Timber frame with brick outer walls; internal walls made of timber & plasterboard

White Space Availability

- Testing was carried out using CWSC's Non-Operational Development (T&D) licence.
- Database indications of white space availability vary:





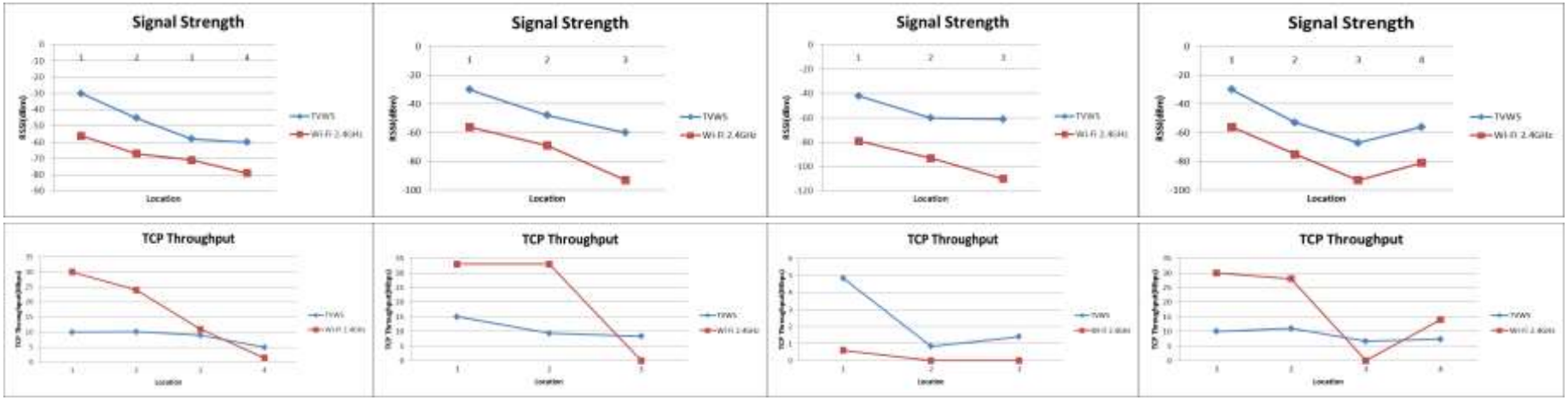
Radio Configuration

Attempted to configure 802.11af and 802.11n radios as ‘similarly’ as possible:

- Bandwidth:
  - 802.11n: 20 MHz
  - 802.11af: 8 MHz
- Transmit Power:
  - 18 dBm for both 802.11n and 802.11af
- Antennas:
  - 802.11af: Omni (~1 dBi)
  - 802.11n @ 2.4 GHz: Built-in antenna (~5 dBi)
  - 802.11n @ 5 GHz: Built-in antenna (~7 dBi)
- MIMO:
  - No MIMO: All devices were configured to run SISO.

Results

- RF coverage:
  - Received signal strength for 802.11af was typically 20-40 dB greater than that of 802.11n.
  - 802.11af: Good penetration, able to deliver coverage throughout the home, and even outside into garden areas.
  - 802.11n @ 2.4 GHz: Reasonable, but loses connectivity after a couple of brick wall penetrations.
  - 802.11n @ 5 GHz: Good when operating in the same room or with LOS, but struggled to penetrate beyond a room boundary. (N.B. MIMO was disabled for these tests, forcing SISO operation.)
- Data throughput:
  - When sufficient signal strength was available, 802.11n was capable of supporting data rates about 2-3 times greater than those of 802.11af. (N.B. Bandwidth was 20 MHz for 802.11n and 8 MHz for 802.11af.)
- Full HD video streaming:
  - 802.11af could support Full HD video streaming only if ~15 Mb/s was achievable. This required LOS or 'same room' operation. (N.B. Production version is expected to be capable of supporting data rates up to 20 Mbit/s in a single TV channel, and, in addition, will support bonding of up to 4 channels, subject to white space spectrum availability.)



Conclusions & Recommendations

- 802.11af has significant potential to complement existing 802.11 technologies and to improve in-home coverage.
  - Maximum (LOS) 802.11af data rates are not as high as maximum (LOS) data rates for 802.11n, although channel bonding will help to narrow the gap here.
  - 802.11af has good penetration characteristics, allowing coverage to be supported throughout most of the home and in some cases into the external garden.
- The tests were carried out in a very small number of locations within each home. More detailed testing, using a greater number of test points, would allow a more complete coverage picture to be formed.
- No attempt was made to test the effects of 802.11af transmissions on DTT reception. This would be a useful test to carry out in future.
- It would also be useful to carry out the tests using geo-location database spectrum access control in each home.
- However, test time is a limiting factor – the home-owner's patience runs out after a couple of hours!

For further information, please visit:

www.wirelesswhitespace.org