Self-backhauling in 5G

Alain Mourad

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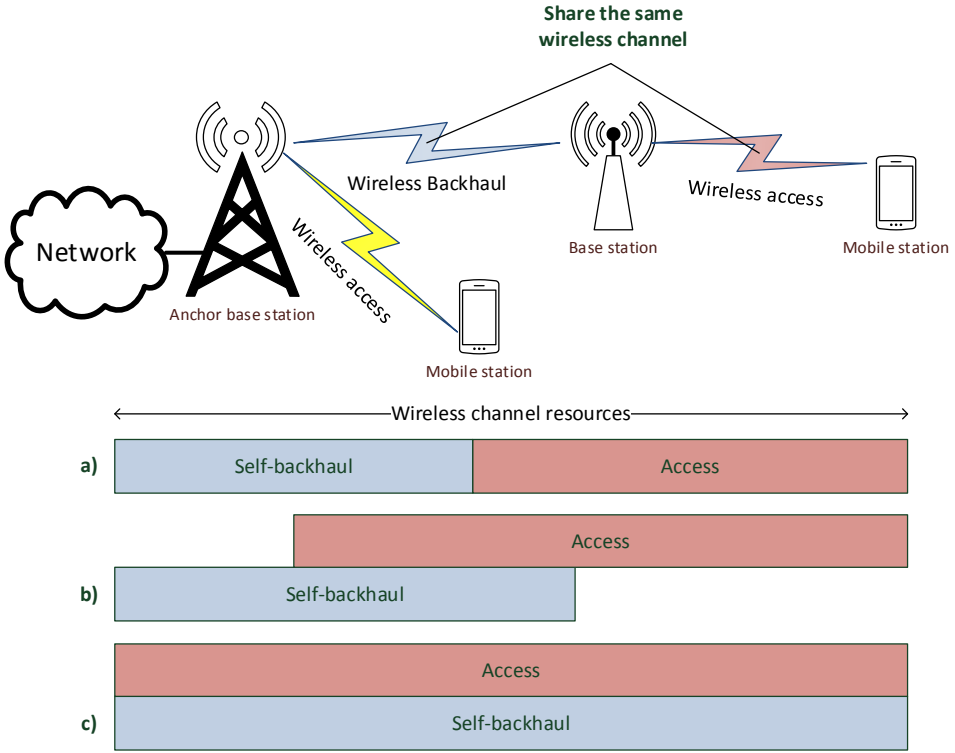
Self-backhauling: The concept

- Self-backhauling defined as when the access (BS-MS) and the backhaul (BS-BS or BS-Network) **share the same wireless channel**
- Sharing options of the wireless channel resources (Time, Frequency, and Space):
  a) Orthogonal (no reuse)
  b) Partial reuse
  c) Full reuse (one)



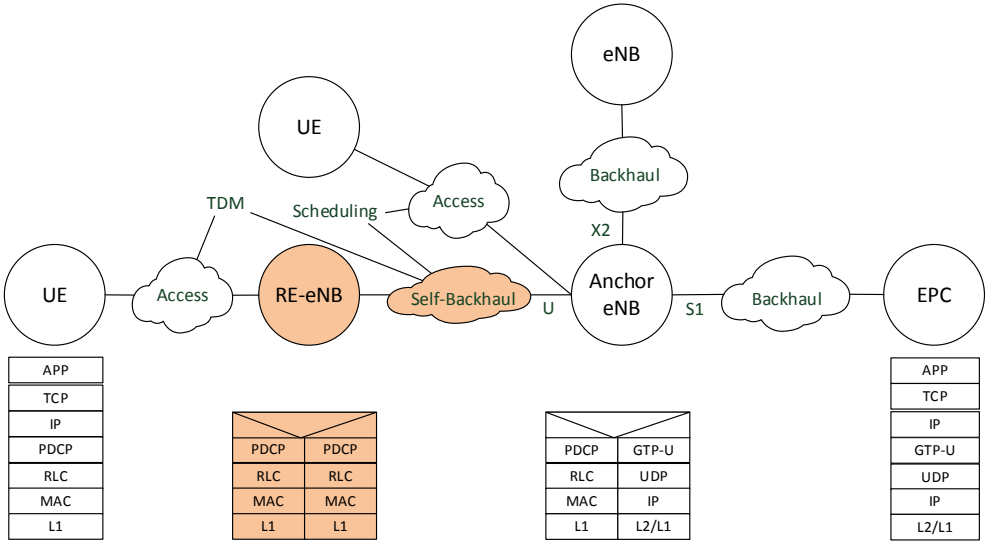
The pros and cons

- **The pros**
  - Higher spectrum efficiency
    - Reuse of time, frequency and space resources between access and backhaul
  - Higher cost efficiency
    - Sharing the same radio hardware unit
    - Sharing same O&M systems, simplifying system management
  - Higher Performance
    - Lower latency (Receive and Forward simultaneously)
    - Dynamic optimization of resource across access and backhaul

- **The cons**
  - A new type of interference (access-backhaul interference) to mitigate
  - Sophisticated (complex) scheduling of the channel resources (across two domains, access and backhaul)
  - Potential limitations on the end user experience (e.g. rate, latency) due to the sharing of resources between access and backhaul
  - Regulatory framework for spectrum rules may not be in place

Current application in 3GPP (LTE-A)

- Self-Backhauling is used in 3GPP LTE for PtP relaying at Layer 3 (for backwards compatibility)
- It enables using LTE-A radio resources for eNB backhauling
- Frequency or Time division multiplexing between access and backhaul at RE-eNB
- Coordinated scheduling between RE-eNB and Anchor eNB

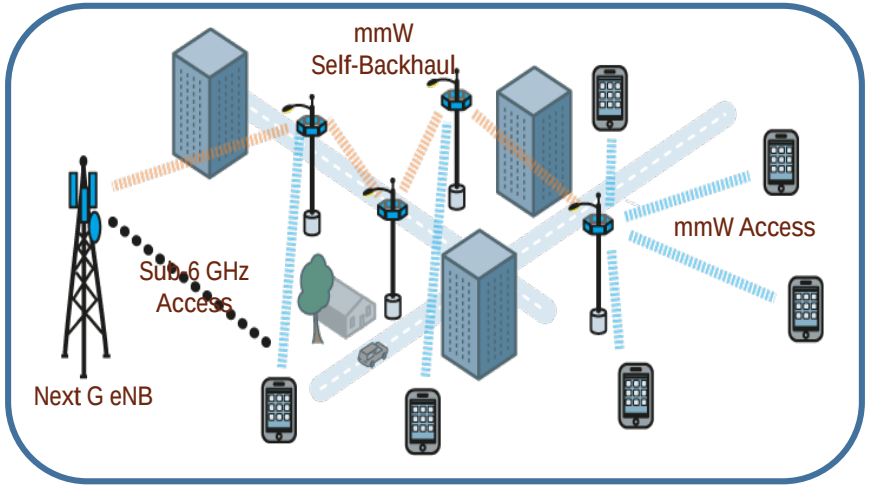


Drivers for self-backhauling in 5G

- Small cells densification calling for **cost-effective and low latency** backhauling
  - Wireless backhaul as cost-effective alternative to fiber
  - Low latency backhaul for tighter inter-cell coordination towards interference management and reduced number of handovers
- 1000x traffic increase calling for **Gbps backhaul** capacity, which requires new spectrum (e.g. mmWave) that is also required for access
- Use cases are driving backhaul technology to be similar to access
  - Mobile backhaul for vehicles, trains etc.
  - NLOS street-level small cell backhaul
  - Access links extending to higher frequencies
- Goal to maximize efficiency through joint optimization/**integration** of access and backhaul resources
- Overall simplification by using same technology for access and backhaul

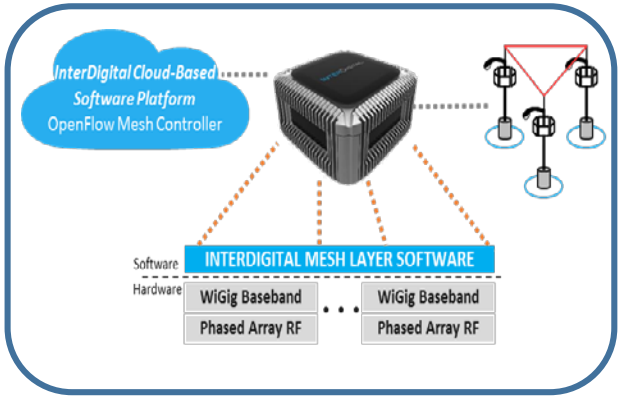
Particular suitability in mmWave

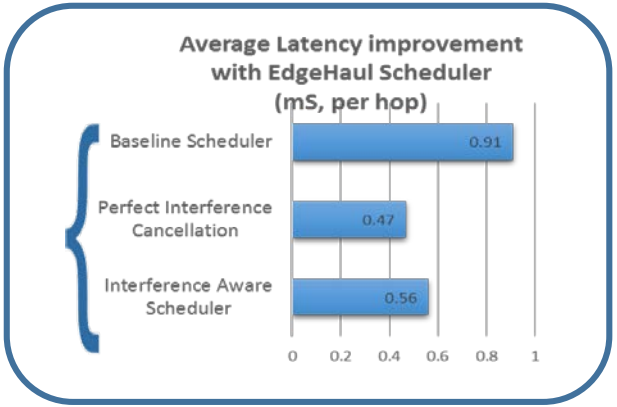
- Large bandwidth per channel, so **best if reused** amongst multiple links
- High-gain, directional and steerable beams for **controlled spatial isolation** between the links
- Per-link **TDD** (based on current link traffic conditions) thanks to high-degree of spatial isolation
- Synergistic with dense-deployments supporting **multi-hop backhaul** with manageable interference between the hops (substantially different from current 3GPP PtP relay architecture)



Exemplary solution: EdgeHaul

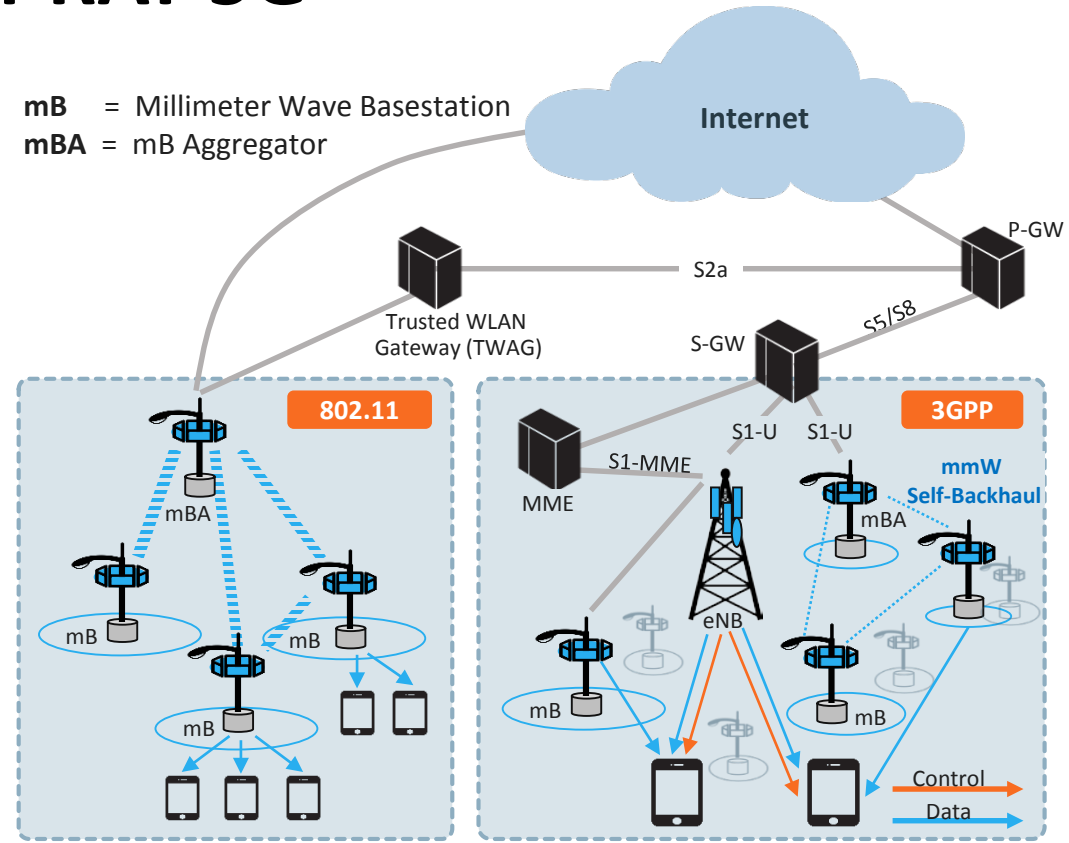
- **EdgeHaul™ - mmWave Wireless Transport**
  - **A Low-cost, high capacity**, scalable design for today's small cell backhaul and future 5G mmWave access
  - **60GHz Phased Array** with electronic beam steering reduces installation cost and provides interference management
  - **Multi-hop framework** enables high throughput over range suitable for urban small cells
  - **Centralized SDN-based control** for the mesh network
  - **Carrier-grade solution** providing per-flow traffic prioritization





Application in multi-RAT 5G

- **mmW underlay** integrated with RAN architecture – with macro eNBs and 4G/5G small cells
- **Multi-hop** wireless backhaul providing fiber-like capacity
- **Multi-site** backhaul connectivity to enable mmW mobility in the access link across sites
- **Primary RAT (sub-6 GHz) providing control** for the backhaul and secondary RAT both self-backhauled at mmWave

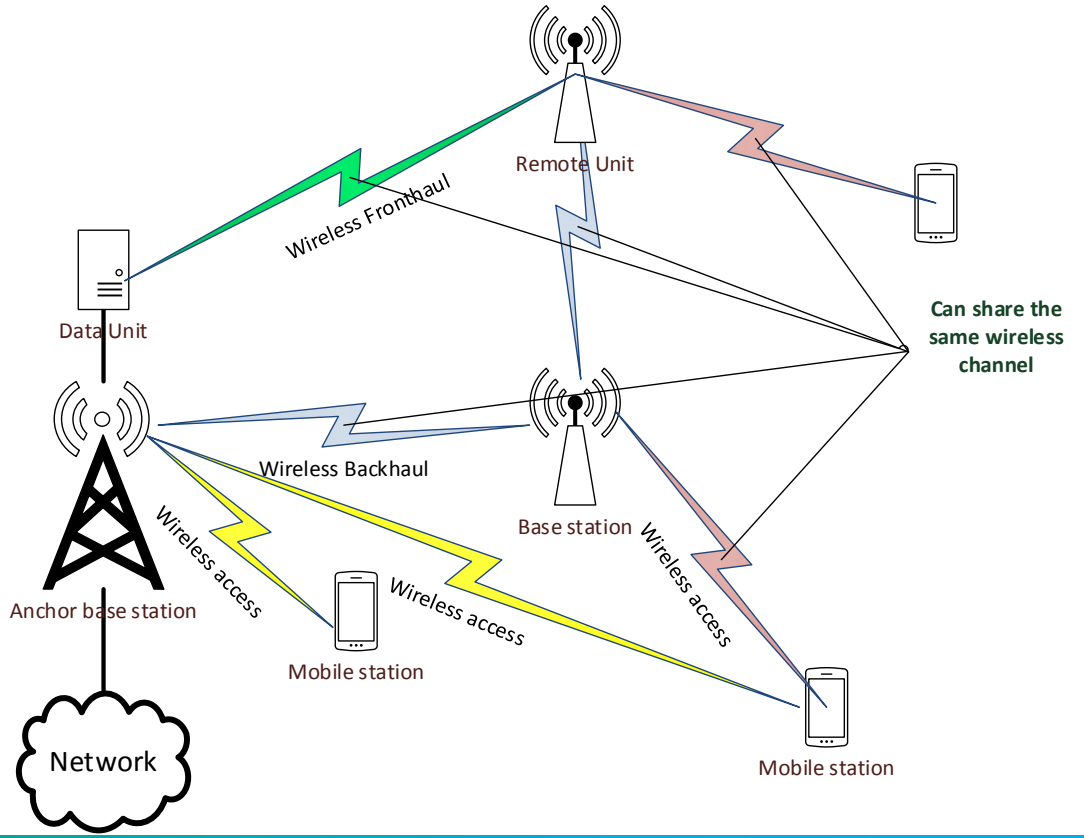


Challenge with emerging new fronthaul (1)

- Fronthaul is an attractive technology for 5G architecture
  - Cost savings result from centralizing equipment into data centers (C-RAN)
  - Enables advanced signal processing for improved spectral efficiency
- Today's **CPRI will not scale for 5G** (1)
  - 1x20MHz LTE carrier with 4T4R consumes 4.9 Gbps | 128T 128R requires ~160Gbps | 1x100MHz 5G with 8T8R needs 49Gbps
- Emerging fronthaul with **new functional splits** relaxing transport requirements (capacity, latency), enabling packetization, and ensuring scalability
- Business case requires support for **wireless fronthaul** (fiber too costly to put everywhere)
- RAN Architecture may need re-design to embrace **virtualization in the access** (where and when it is beneficial) and properly implement fronthaul
  - Standardization of flexible functions splits between RU and DU
  - Joint optimization across Access/Backhaul/Fronthaul (BH/FH focus of 5G-Crosshaul)

Challenge with emerging new fronthaul (2)

- Will self-backhaul extend to cover **wireless fronthaul**?
- How to go about the **integration of access, fronthaul, and backhaul**, especially as they might share the same wireless channel?



Conclusions

- Targeted 5G use cases and KPIs call for a new thinking of self-backhauling beyond its current PtP L3 relay use in 3GPP (4G)
- Particular suitability in mmWave spectrum thanks to inherent high spatial isolation, high capacity, and multi-hop (range) links
- Technology feasibility is asserted (through solutions like EdgeHaul) but challenges remain (e.g. complexity, spectrum regulation)
- Open questions:
  - How deep will self-backhauling go into the 5G **access/backhaul** integration story?
  - Will it extend to emerging wireless fronthaul to become **self-crosshauling**?!
  - If yes, what is being done today (e.g. in 5G-PPP) for the integration framework across **Access/Backhaul/Fronthaul**, including self-crosshauling?
  - What **standardization forums** should be targeted best for self-crosshauling (e.g. 3GPP, IEEE 1914, others?)?

Thank You!

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