



Filter Bank Ultra-Wideband Communications

September 2024

Changing the World's Energy Future

Brian David Nelson, Behrouz Farhang



INL is a U.S. Department of Energy National Laboratory operated by Battelle Energy Alliance, LLC

DISCLAIMER

This information was prepared as an account of work sponsored by an agency of the U.S. Government. Neither the U.S. Government nor any agency thereof, nor any of their employees, makes any warranty, expressed or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness, of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. References herein to any specific commercial product, process, or service by trade name, trade mark, manufacturer, or otherwise, does not necessarily constitute or imply its endorsement, recommendation, or favoring by the U.S. Government or any agency thereof. The views and opinions of authors expressed herein do not necessarily state or reflect those of the U.S. Government or any agency thereof.

Filter Bank Ultra-Wideband Communications

Brian David Nelson, Behrouz Farhang

September 2024

**Idaho National Laboratory
Idaho Falls, Idaho 83415**

<http://www.inl.gov>

**Prepared for the
U.S. Department of Energy
Under DOE Idaho Operations Office
Contract DE-AC07-05ID14517**

July 16, 2024

Brian Nelson

Wireless Research
Engineer

Brian.Nelson@inl.gov

Filter Bank Ultra-Wideband Communications

Battelle Energy Alliance manages INL for the
U.S. Department of Energy's Office of Nuclear Energy



Idaho National Laboratory

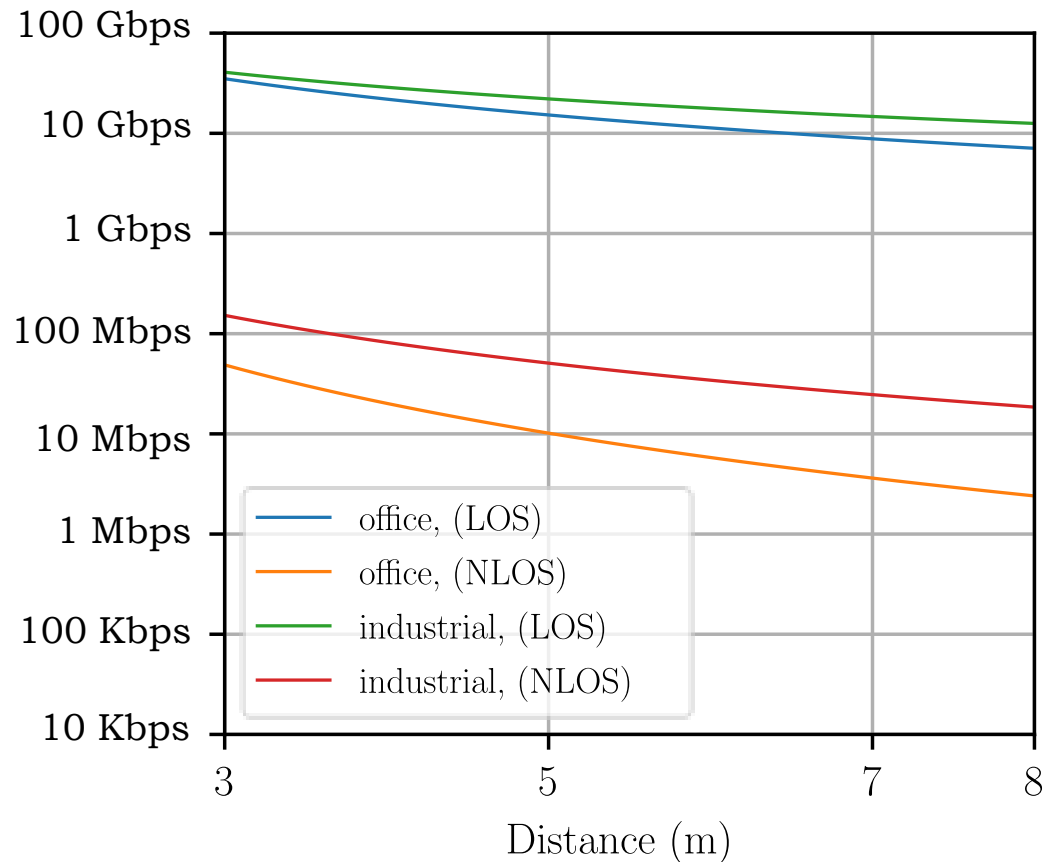
What is missing here?



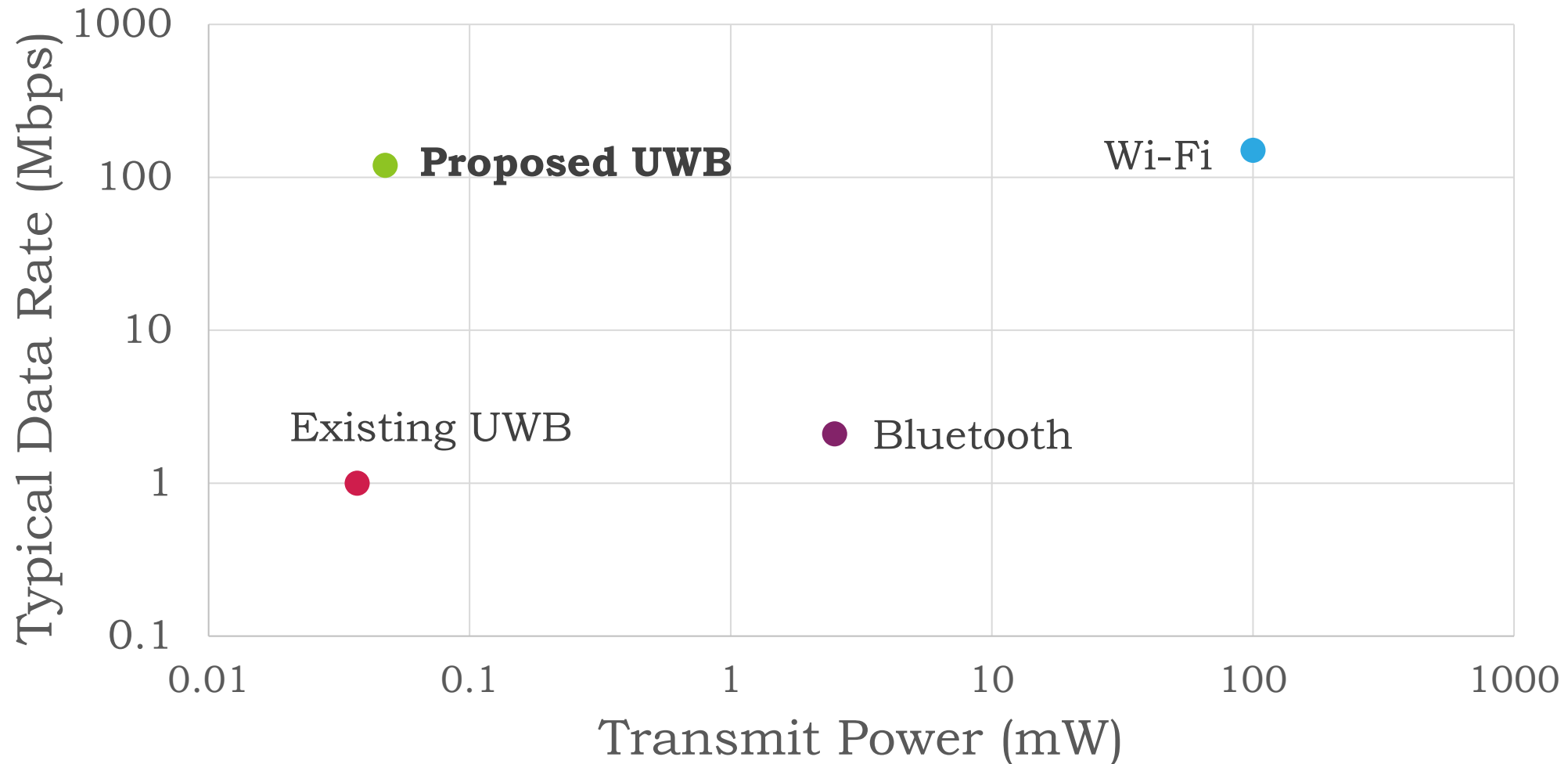
- Wires!
- Imagine wireless systems supporting 4K video streams in
 - Offices
 - Home theaters
 - High-rate sensor networks
- Ultra-wideband (UWB) technology has this potential

UWB technology can have large impacts on consumer and government communications.

- Over short ranges, UWB offers:
 - High data rates ($\geq 1\text{Gbps}$)
 - Low transmission power ($\leq 1\text{mW}$)
 - Spectrum reuse
 - Less observable transmissions

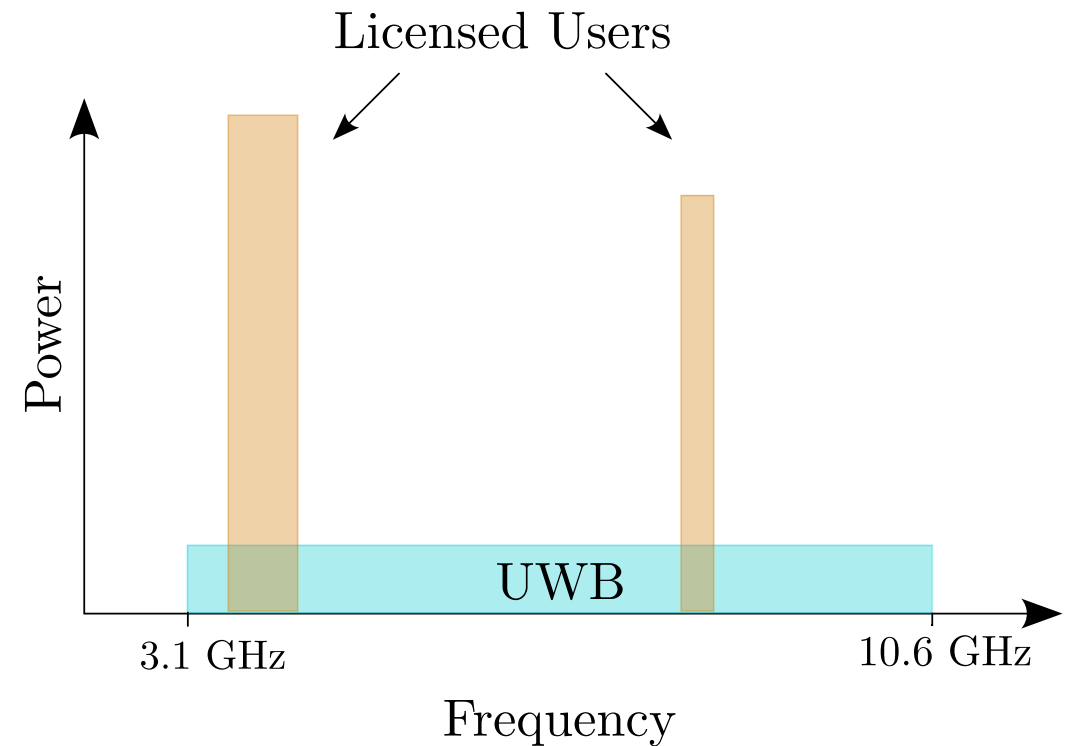


UWB is a low power, wideband class of wireless systems.



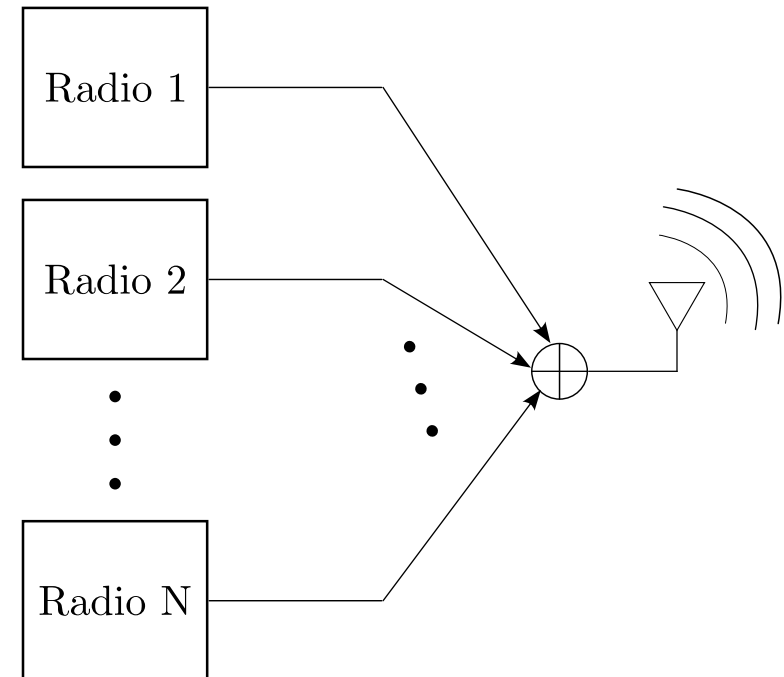
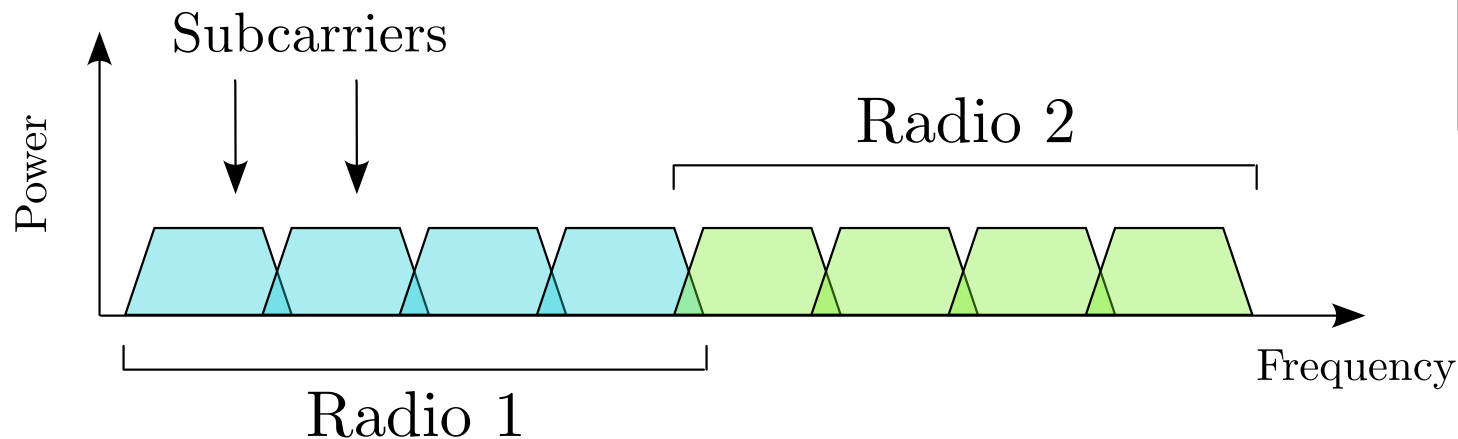
The UWB operating environment has several challenges that have limited the technology's use.

- High samples rates for digital implementations
- High power interference from other technologies such as Wi-Fi, cellular, and radar
- A harsh multi-path channel



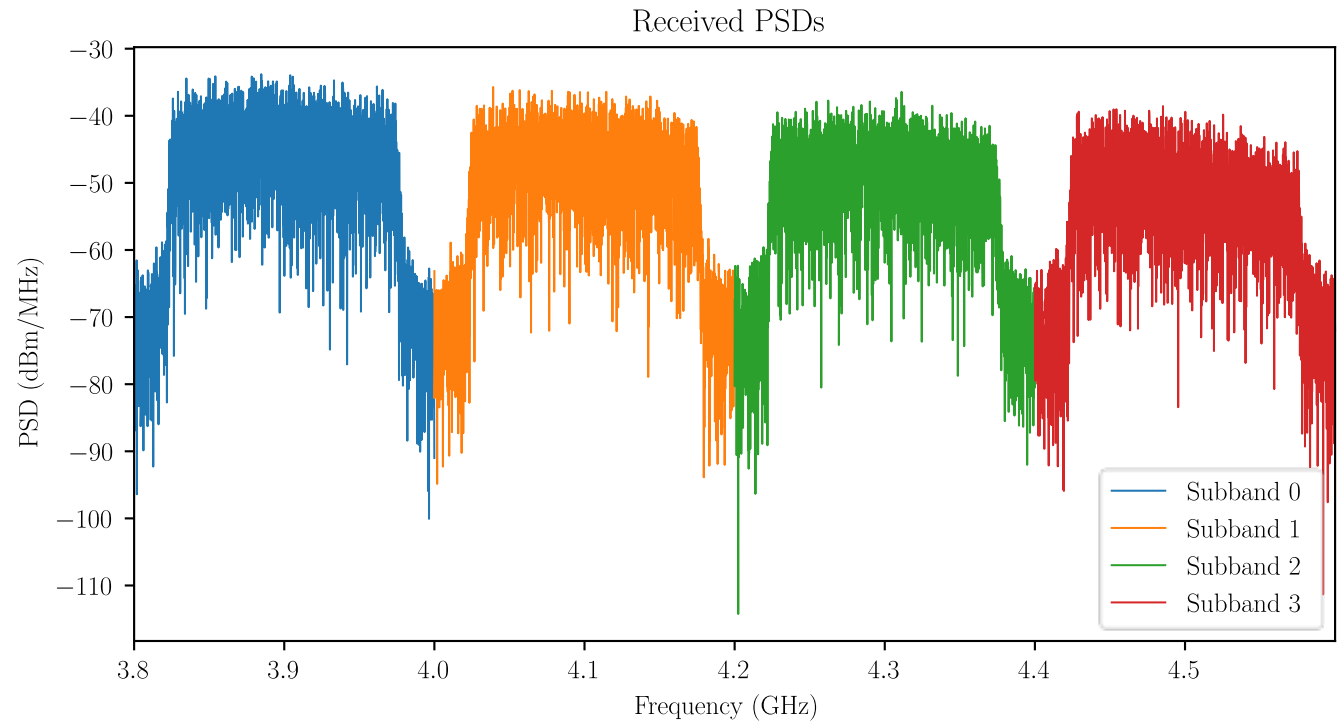
An alternative technology based on filter banks can realize UWB's potential.

- Our approach is based on filter bank multicarrier (FBMC) communications.
- Sub-bands are synthesized and processed on separate radios.
- Each sub-band consists of many narrow subcarriers.



Filter banks are well-suited to address the harsh UWB operating environment.

- Spectrum partitioning results in
 - Power efficient A/D and D/A converters
 - Efficient, parallel digital signal processing solutions
- Straightforward narrowband interference suppression
- Low complexity channel equalization



Our research will culminate in the design and demonstration of a filter bank UWB system.

- **Current progress:**
 - Thorough study of UWB, filter banks, and multi-coding techniques
 - Initial system design
 - UWB simulation environment
 - Survey of the UWB interference environment
- **Next steps:**
 - Signal Detection
 - Receiver synchronization
 - Over-the-air demonstration



Summary

- UWB designs have the potential for
 - High rate, short range, low power communications
 - Spectrum reuse
 - Less observable transmissions
- Filter bank UWB has several useful properties
 - Spectral partitioning
 - Interference robustness
 - Low complexity channel equalization
- Impacts
 - Licensing opportunities and potential engagement with commercial industry
 - Potential low probability of detection government applications

