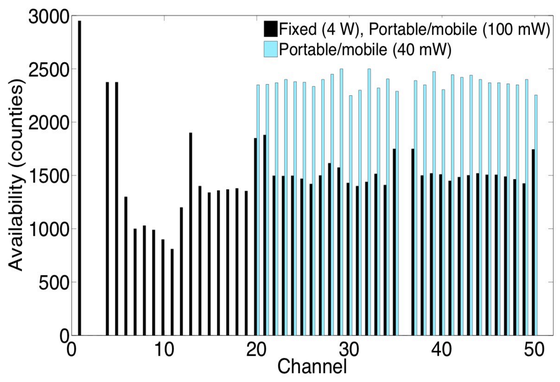
Exploiting White Spaces for Low-Power Long-Range Communication

D. Ismail, M. Rahman, P. Modekurthy, A. Saifullah
Computer Science
WAYNE STATE UNIVERSITY

Motivation

- Large-scale and wide-area wireless Sensor Network (WSN) needs to connect thousands of sensors.
- WSN requires numerous devices to cover a large area.
- Low-Power Wide-Area Network (LPWAN) overcomes the range limitations and scalability problems in WSN.
- Sensor Network over White Spaces (**SNOW**) is a new highly scalable LPWAN technology operating over white spaces.
- White spaces refer to the allocated by locally unused TV spectrum.



Exiting LPWAN Technologies

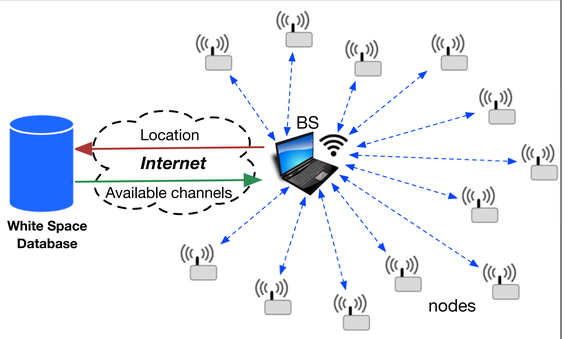
Long Range (LoRa) and SigFox [1, 2]:

- Very recent LPWAN technologies that operate in unlicensed ISM band.
- Their devices require **duty cycled** transmission of 1% or 0.1%.

Existing LPWAN Technologies Cont.

- LoRa employs Orthogonal Variable Spreading Factor (OVSF), requiring mutually orthogonal codes. **Not scalable**
- Less suitable for real-time communication. **Duty cycled**
- With max. data rate of 1Kbps, 12 bytes message, SigFox takes **3 seconds** to transmit a packet.
- Limited number of messages per day (140 message).
- **SNOW overcomes the limitations of existing techniques.**

SNOW Overview

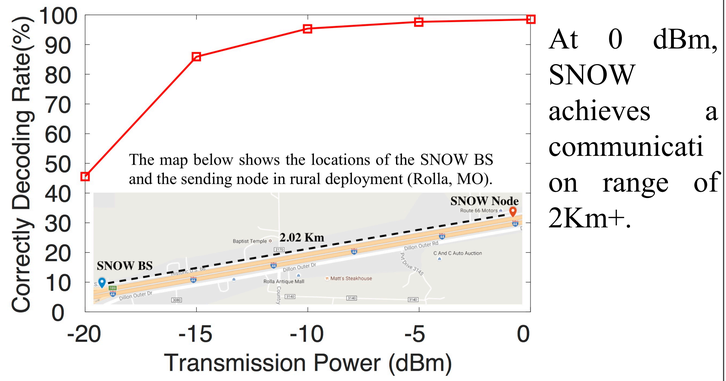


- SNOW has a star network topology.
- The sensors are equipped with a single half-duplex narrowband white space radio.
- The BS uses a wide channel split into orthogonal subcarriers of equal bandwidth.
- The PHY-layer uses Distributed OFDM (Orthogonal Frequency Division Multiplexing) **D-OFDM**, allowing multi-user access.

Implementation of SNOW

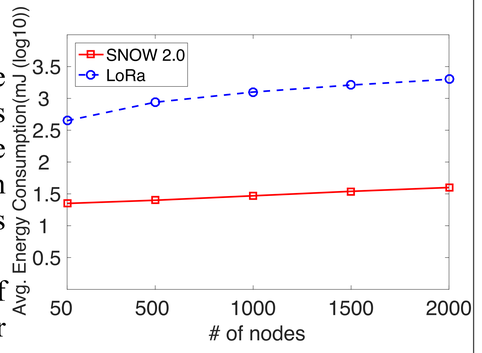
SNOW is implemented in GNU-Radio [3] using Universal Software Radio Platform (USRP) [4] device for the BS and Texas Instrument CC1310 as SNOW node.

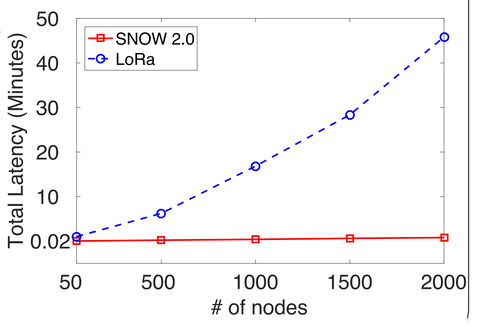
Experimental Results



At 0 dBm, SNOW achieves a communication range of 2Km+.

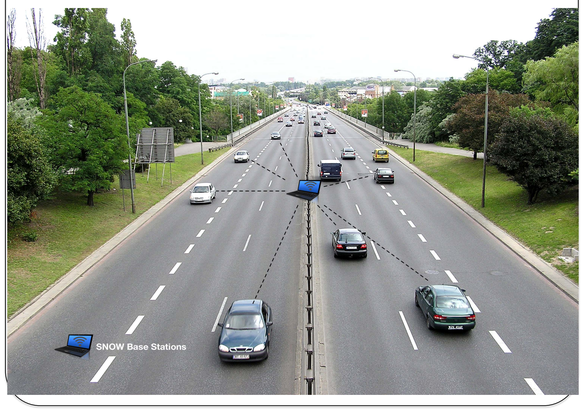
For 2000-node network, the packets are collected at the SNOW BS within 0.79 minutes consuming 22.22mJoules of avg. energy per node. In comparison, LoRa gateway required 45.81 minutes consuming 450mJoules of avg. energy per node.





Connected Vehicle Opportunities

- SNOW supports highly scalable, low-power, long-range, reliable, robust, and fully asynchronous communication.
- Vehicle-to-Vehicle (V2V) and Vehicle-to-Everything (V2X) communication requires reliable and real-time connectivity.
- SNOW is a promising technology for connected vehicle application.



Conclusion

SNOW represents a novel PHY-layer design, eliminating the scalability limitations in existing LPWAN technologies.

References

[1] LoRa. http://www.lora-alliance.org
[2] SigFox. http://sigfox.com
[3] GNURadio. http://gnuradio.org
[4] USRP. https://www.ettus.com
[5] CC1310. https://www.ti.com