

Extension of Interrogation Zone of Backscatter Sensors with Multiple Interrogators

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Agenda

- Backscatter communication overview
- Multiple zone backscatter communication technology
 - Problem definition
 - Real-time and blind separation of collided backscatters
- Backscatter communications research consortium at Keio university update.

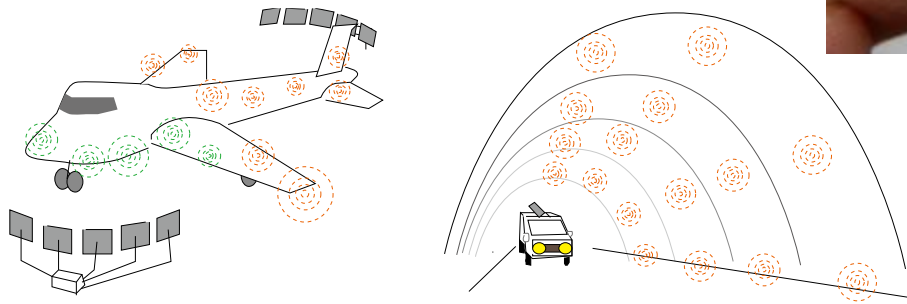
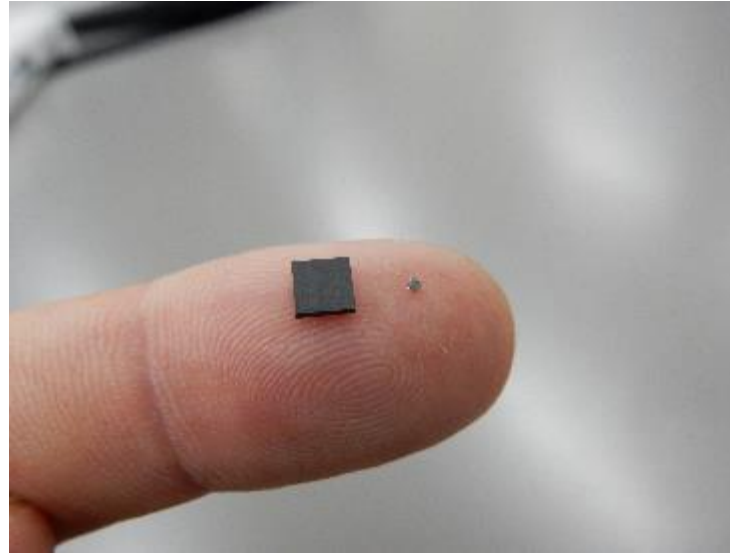
History of Maintenance of artifacts

- First Generation (1940-1950)
 - Reactive Maintenance: Fix when something go wrong.
- Second Generation (1950-1980)
 - Preventative Maintenance: Time-based Maintenance
- Third Generation (1980- present)
 - Predictive/Proactive Maintenance: Condition-based Maintenance

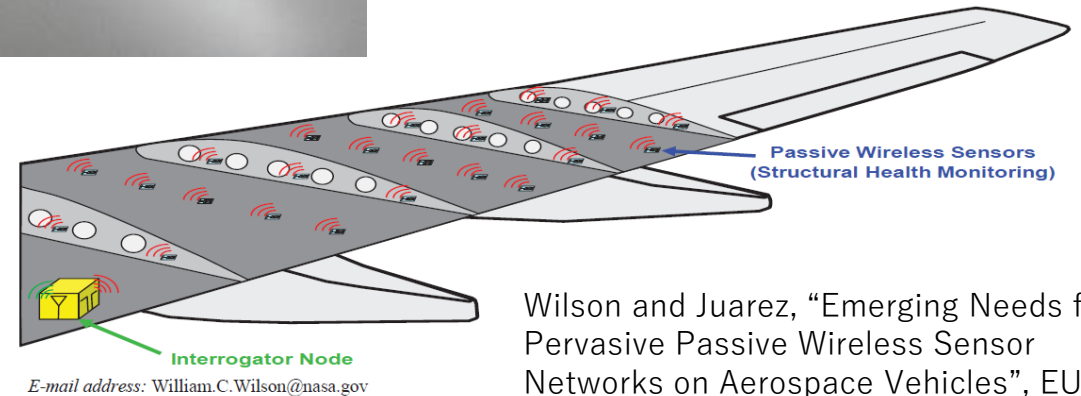
Challenge for Predictive/Proactive Maintenance

- Collect many data including in operation data
- > Batteryless and wireless sensing with ultra small sensors.

Big Picture: Proactive maintenance with implanted batteryless and wireless sensors



Daily sensing/diagnosis without sacrificing the operation



Wilson and Juarez, "Emerging Needs for Pervasive Passive Wireless Sensor Networks on Aerospace Vehicles", EUSPN-2014.

Fig. 1. Concept for pervasive passive wireless sensors for structural health monitoring for aerospace vehicles.

In operation monitoring

Application Area: Aerospace

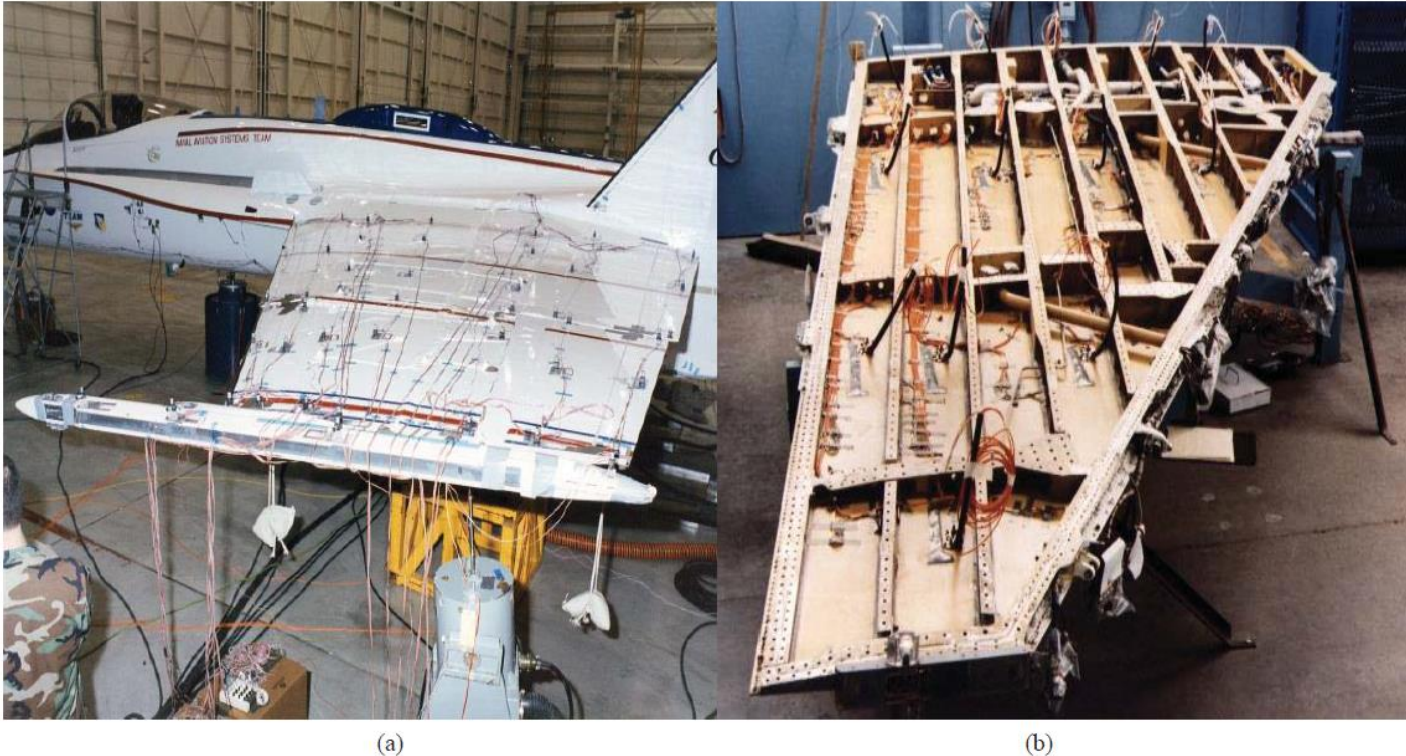
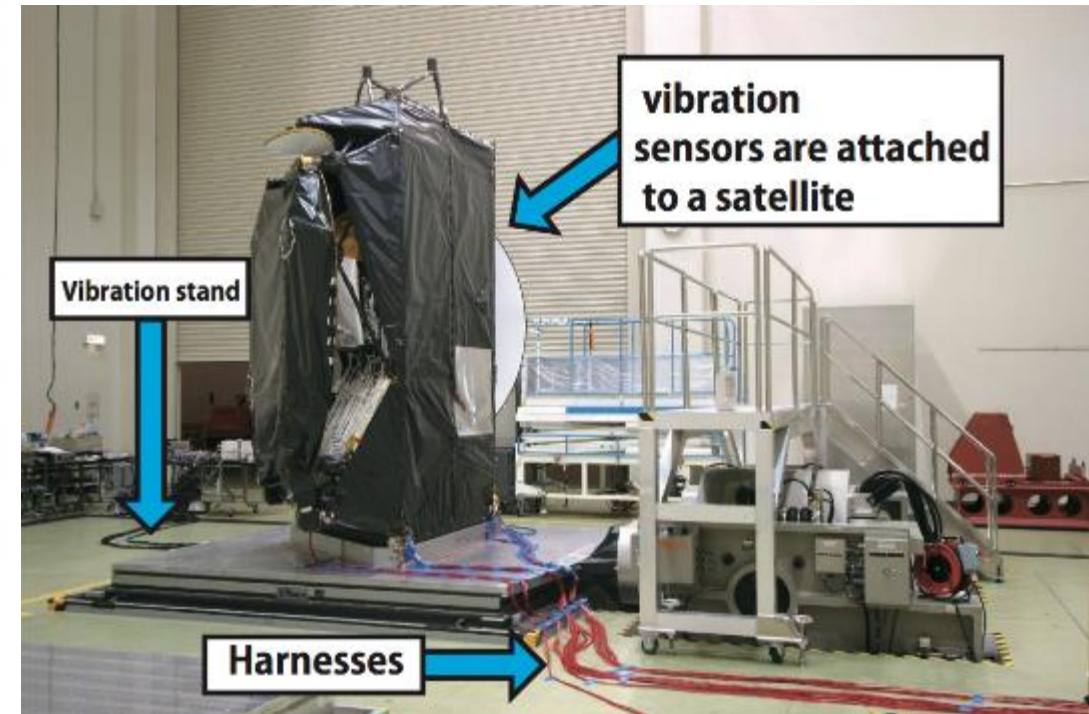
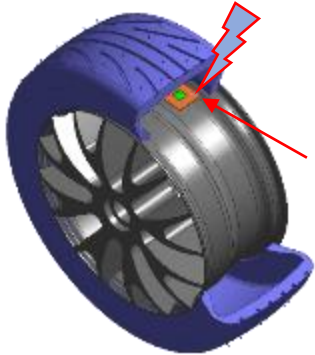


Fig. 6. (a) Accelerometer wiring hanging down from an F/A-18 test aircraft at NASA Armstrong Research Center.
(b) Strain gauge wiring (orange wires) installed on the interior of the AFTI/F-16 wing.

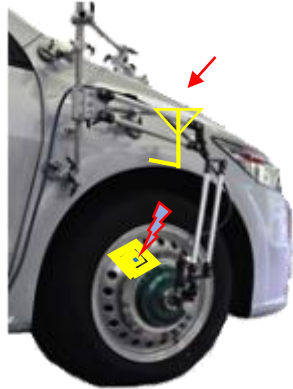


Wilson and Juarez, "Emerging Needs for Pervasive Passive Wireless Sensor Networks on Aerospace Vehicles", EUSPN-2014.

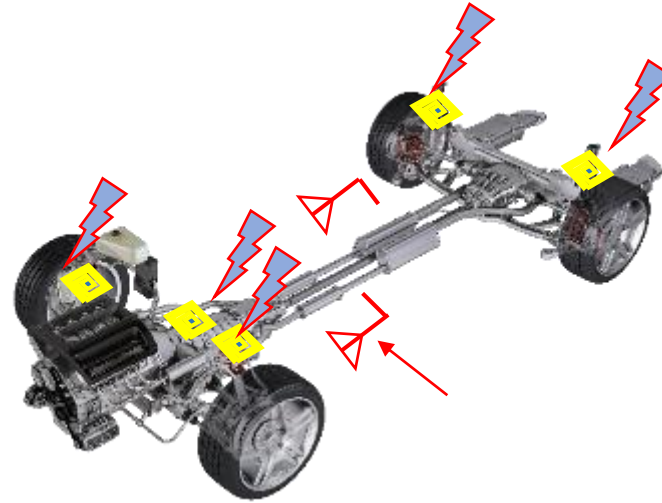
Application Area: Automobile/Industrial Machines



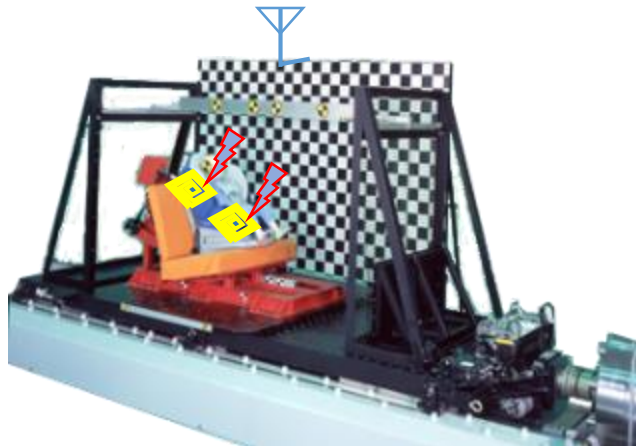
Pressure



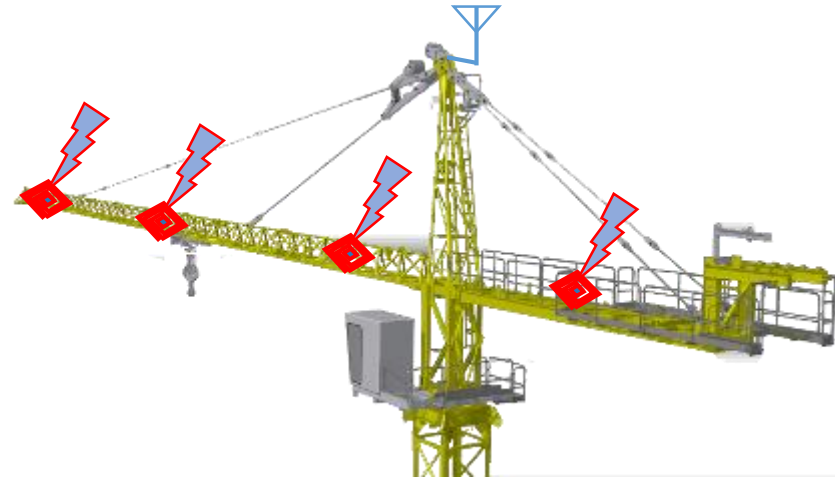
Acceleration



Acceleration Strain



Acceleration



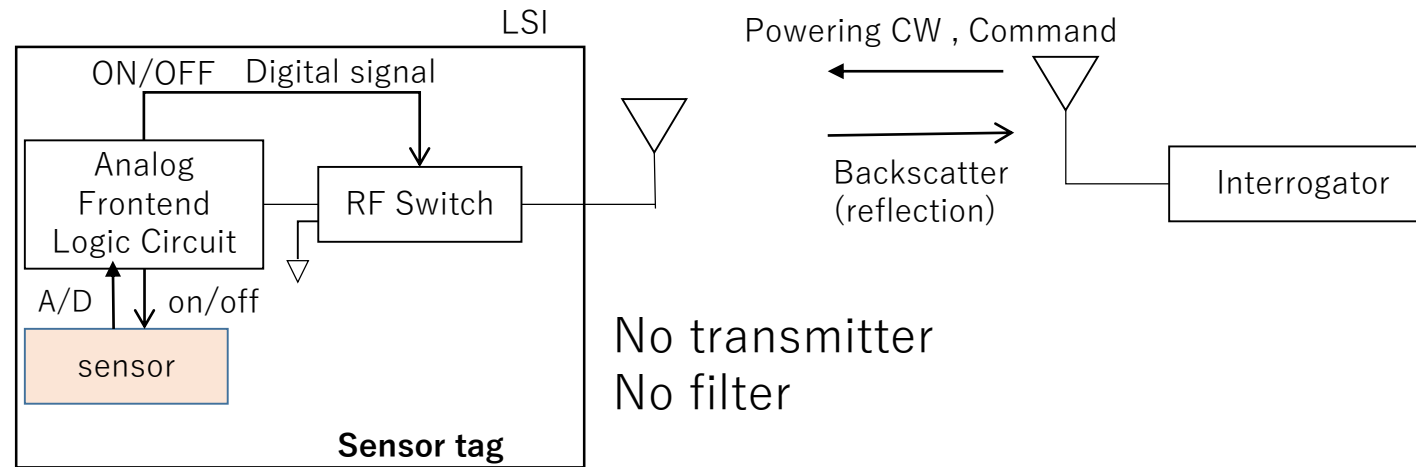
Vibration/Displacement

Wireless SHM requirements

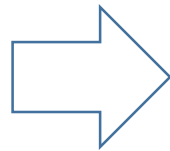
- Sampling rate is from 100 Hz to 1000Hz
- Number of sensors is up to 70
- Sensor data synchronization is below 120 micro second

Noel et.al. "Structural Health Monitoring using Wireless Sensor Networks: A Comprehensive Survey", IEEE Communications Survey, Vol.19, Issue 3, (2017) , pp.1403-1423.

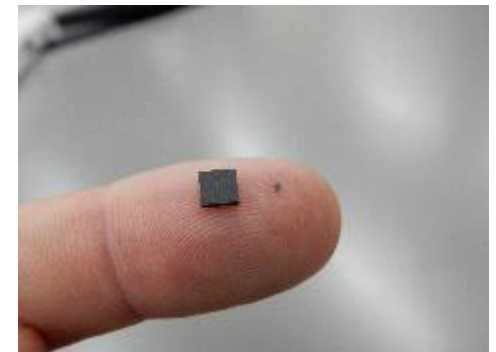
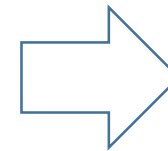
Batteryless and Wireless Sensing with Backscatter Sensors



Battery-assisted with power harvester



Battery-assisted



Batteryless

Pros and Cons of backscatter communication

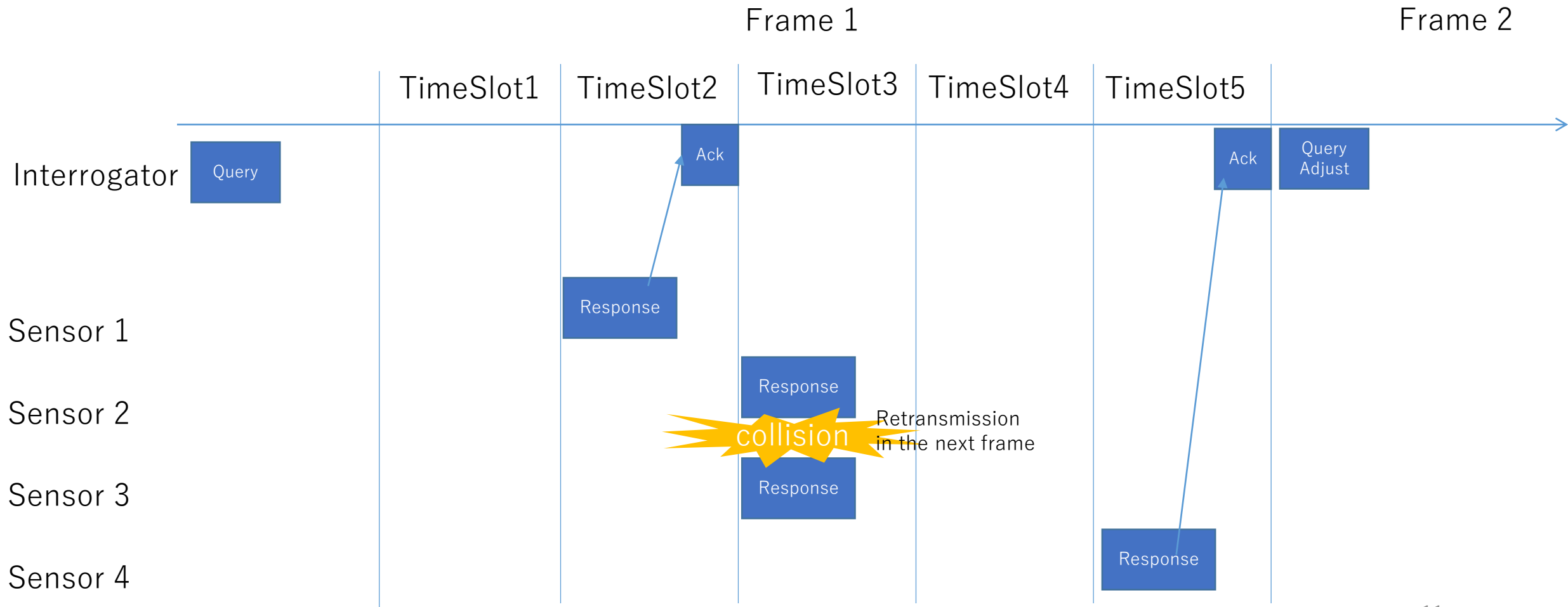
- Pros

- Can be batteryless.
- Sensors can be very cheap and small.
- Non line-of-sight sensing is possible.

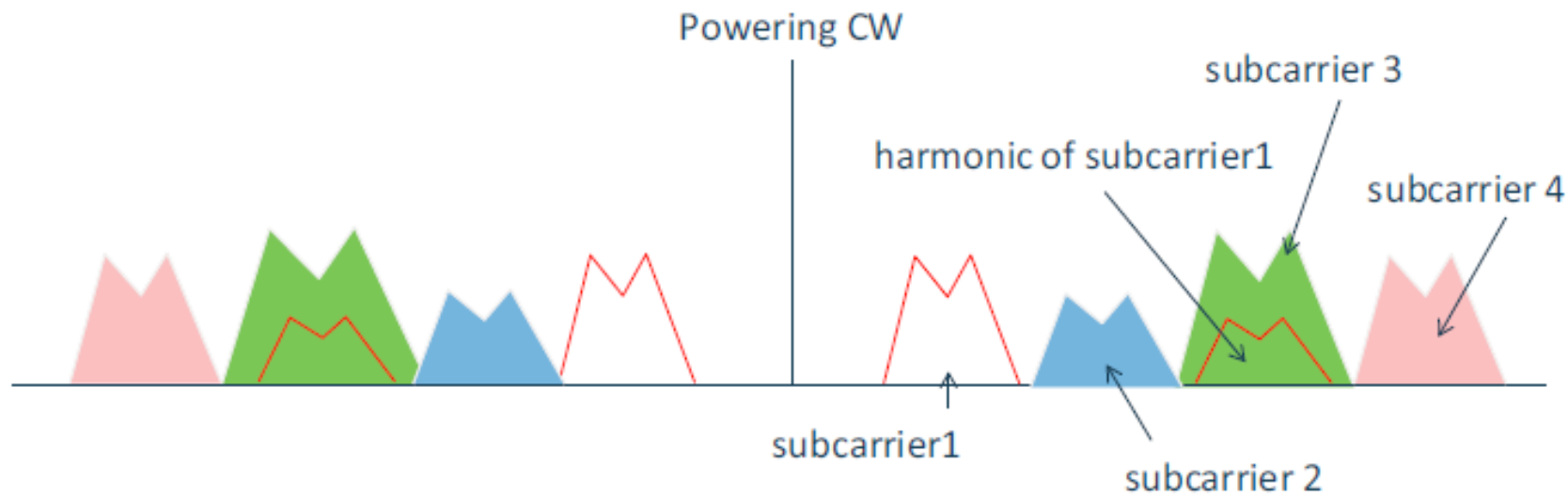
- Cons

- Interrogation distance is short (less than 20m for 4W reader/writer.)
- Concurrent access from sensors is conventionally difficult. (we solved this.)

Traditional multiple access of backscatter system is time division = Concurrent sensing is impracticable

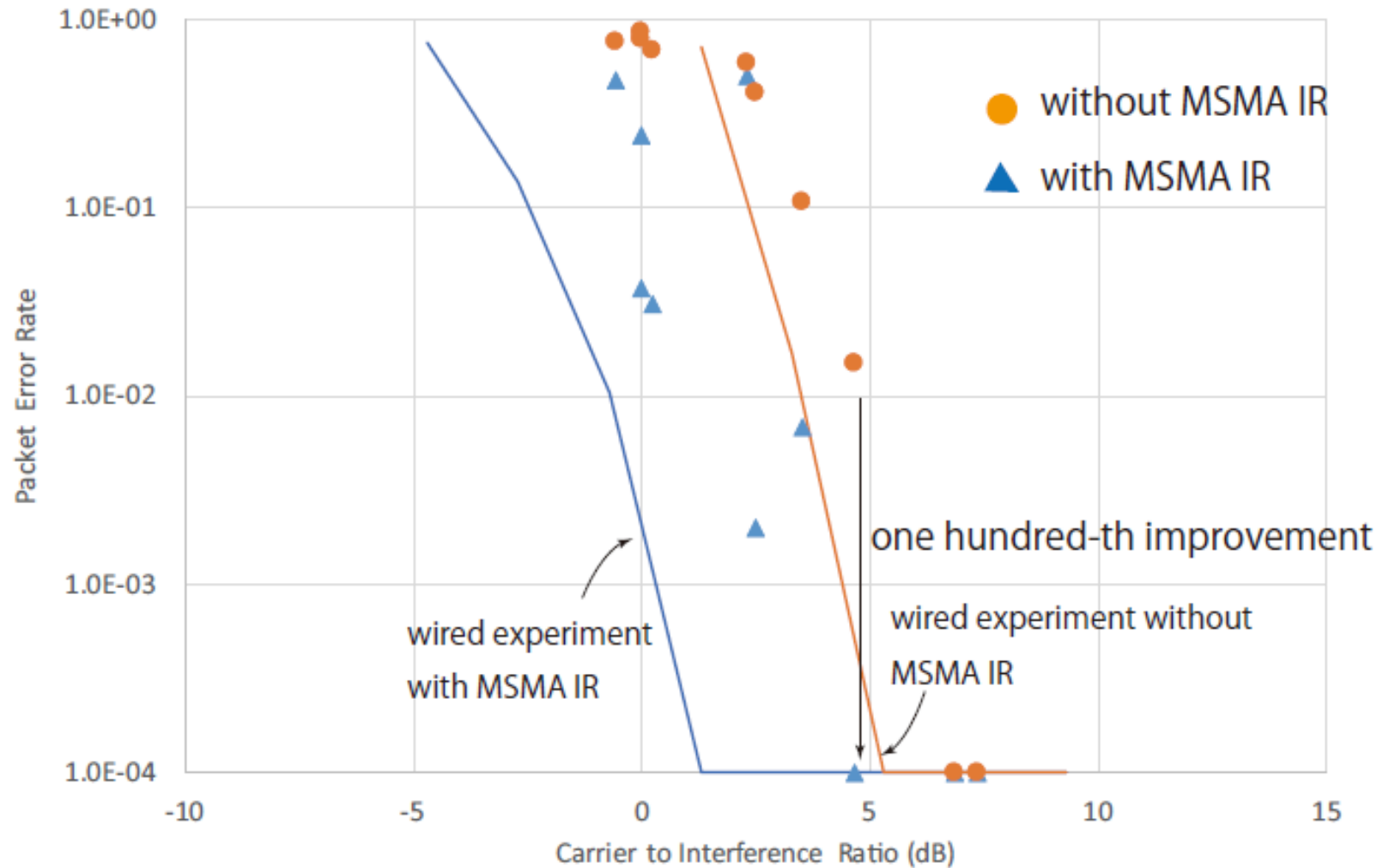


Concurrent use of multiple backscatter causes interference because of the absence of filter



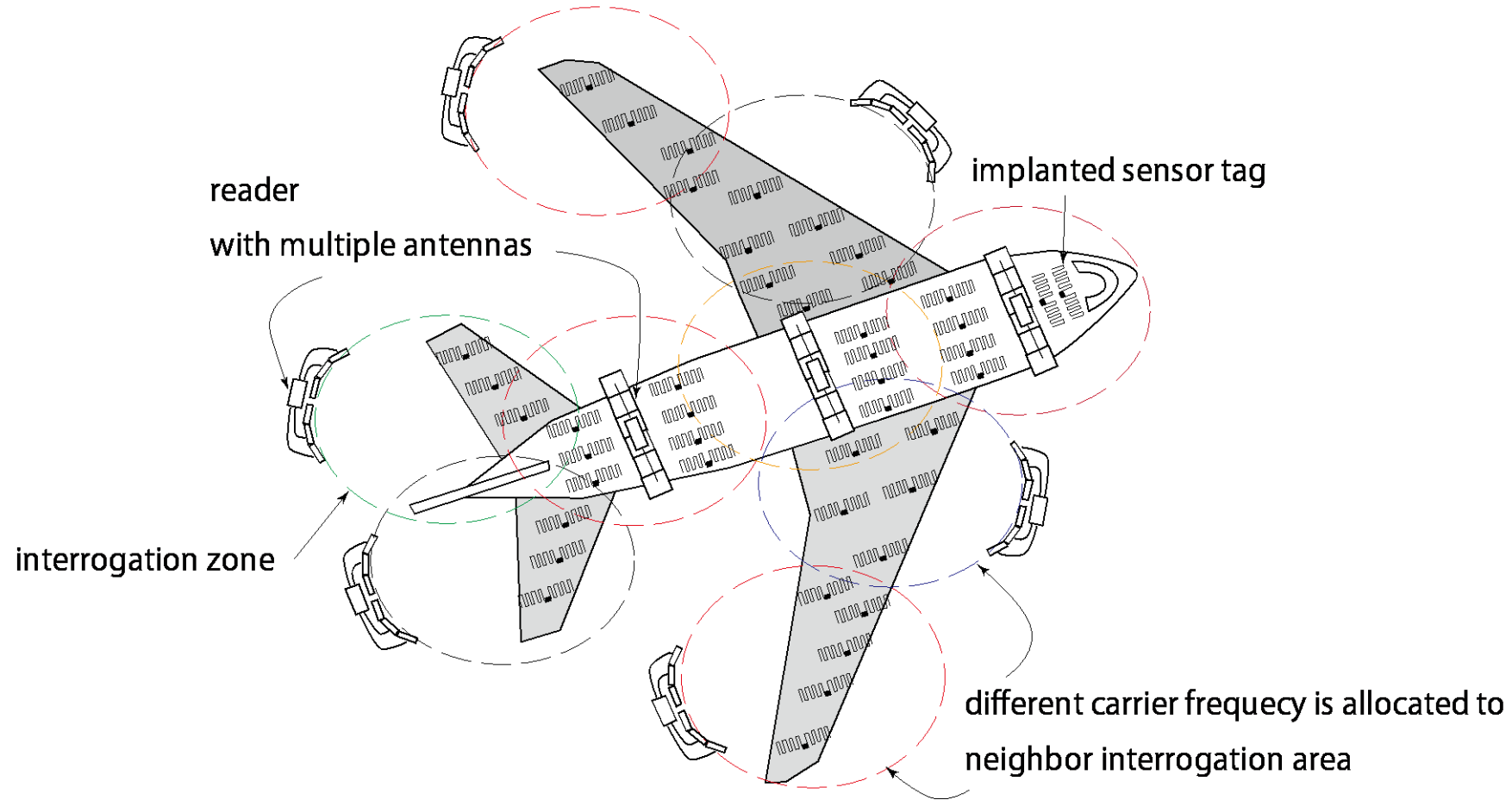
Our idea 1 : harmonic of backscatter can be rejected by signal processing in the interrogator

Interference Rejection Contribution (Indoor Propagation)

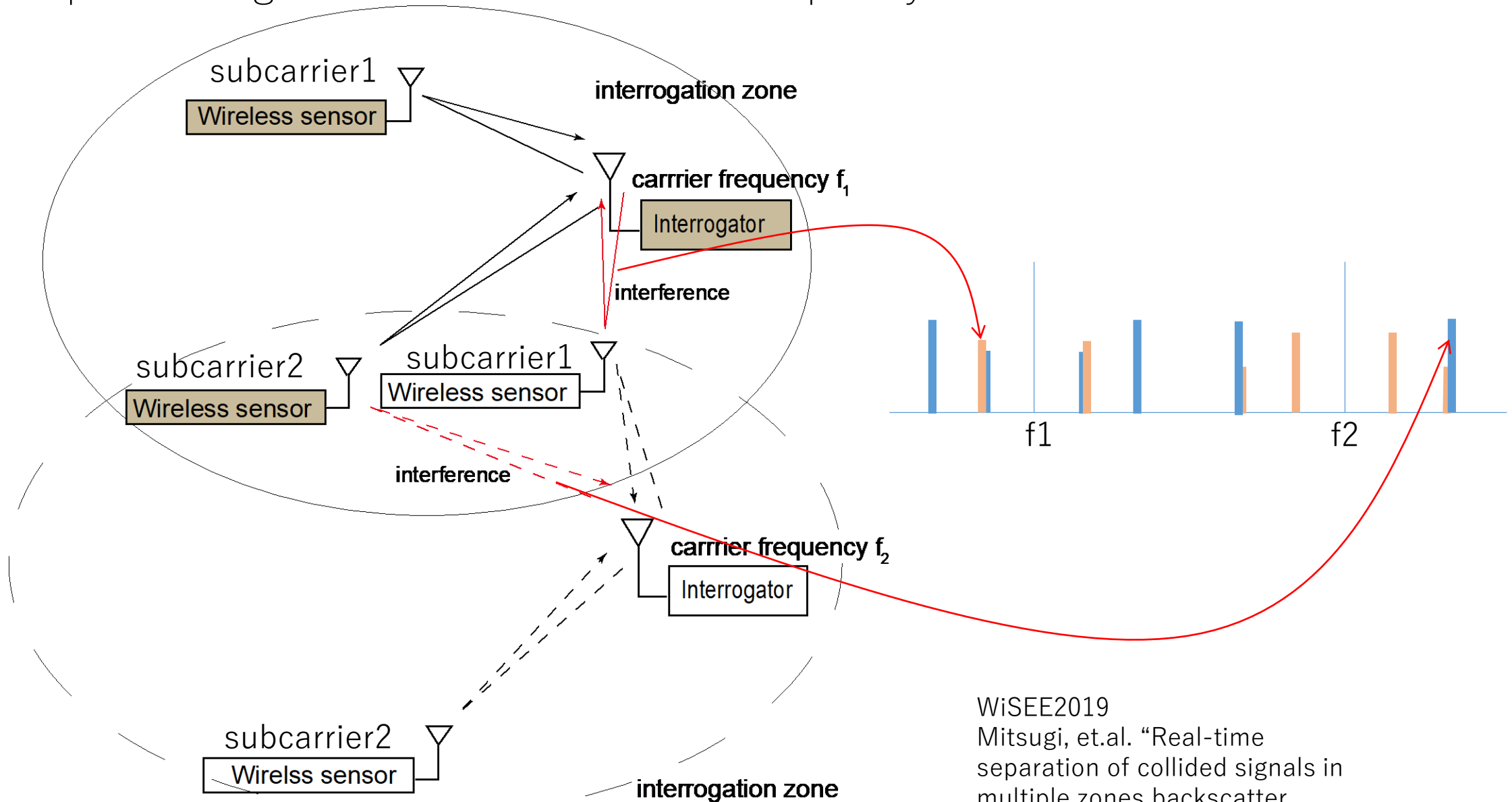


Interference rejection achieves 100 times PER improvement

Extending Coverage with Multiple Zones

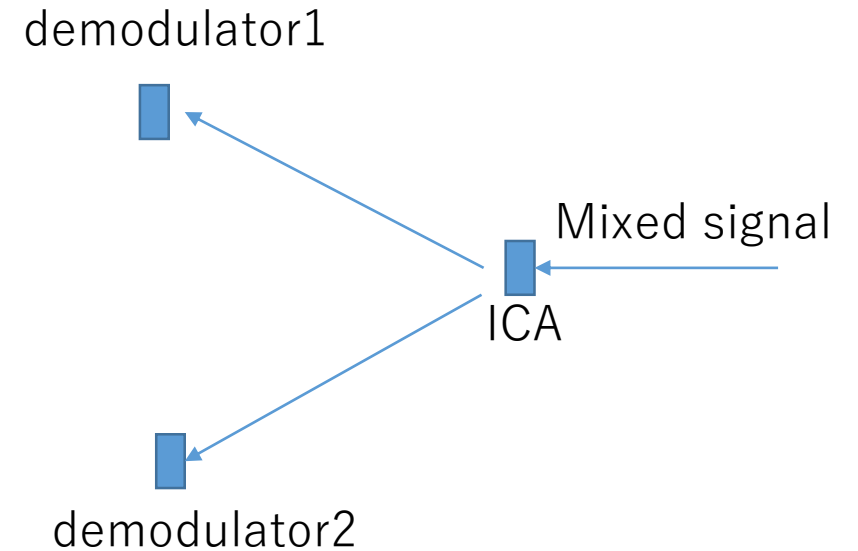
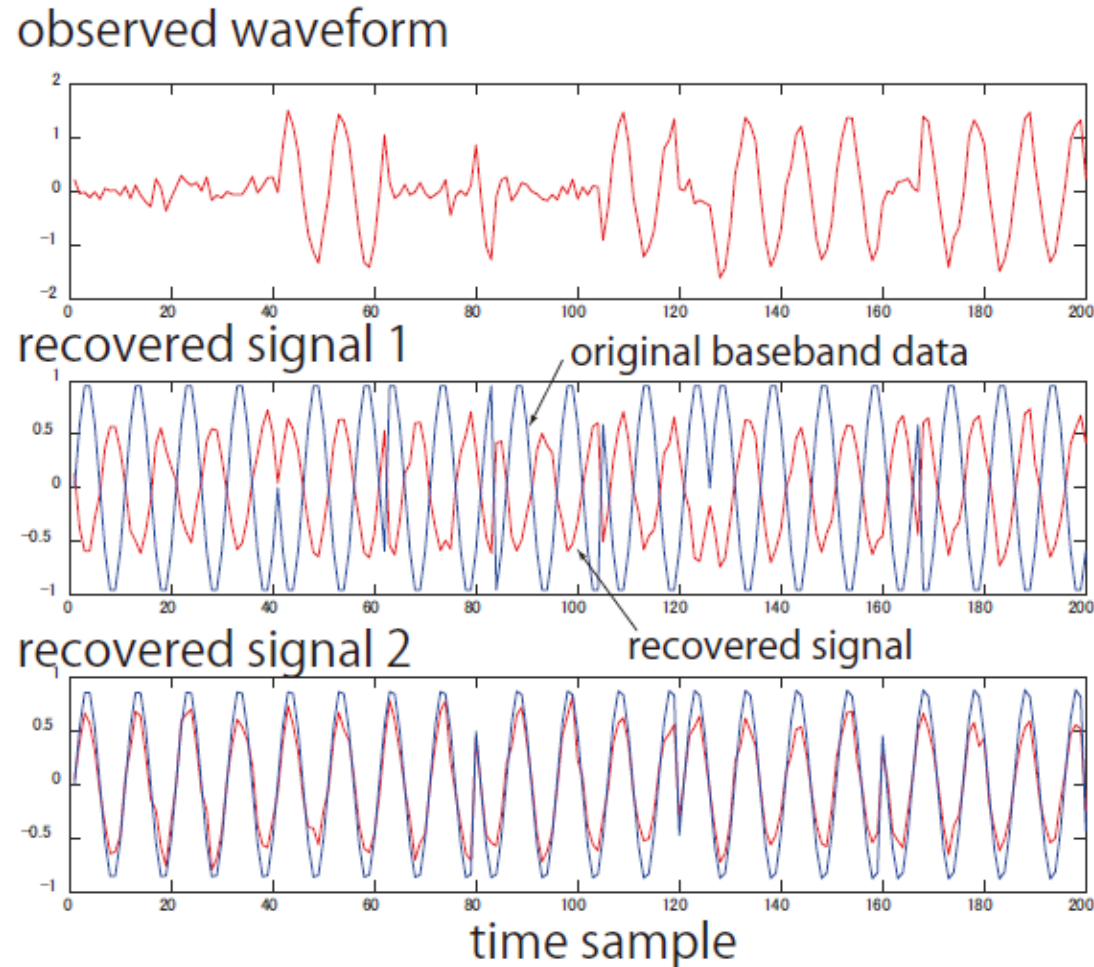


Multi-Zone Problem: Reuse of subcarrier channel is challenging even if we use multiple interrogator with different carrier frequency.

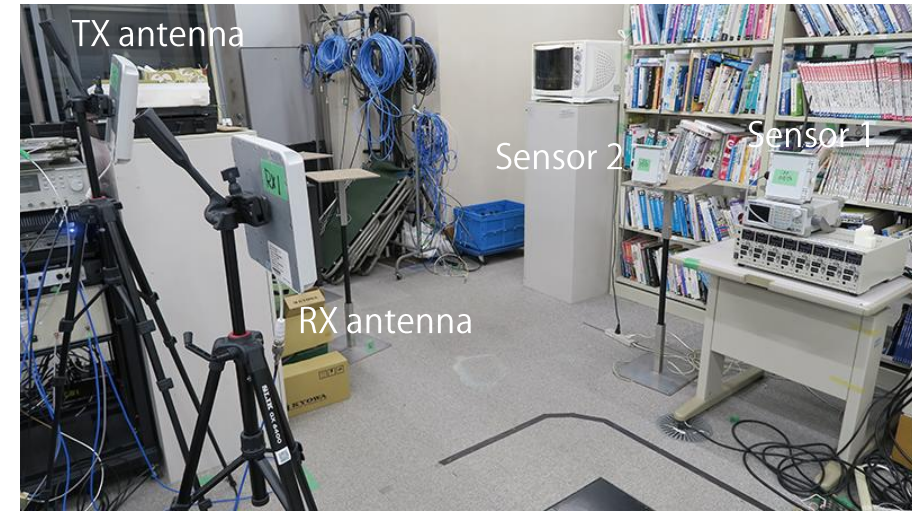
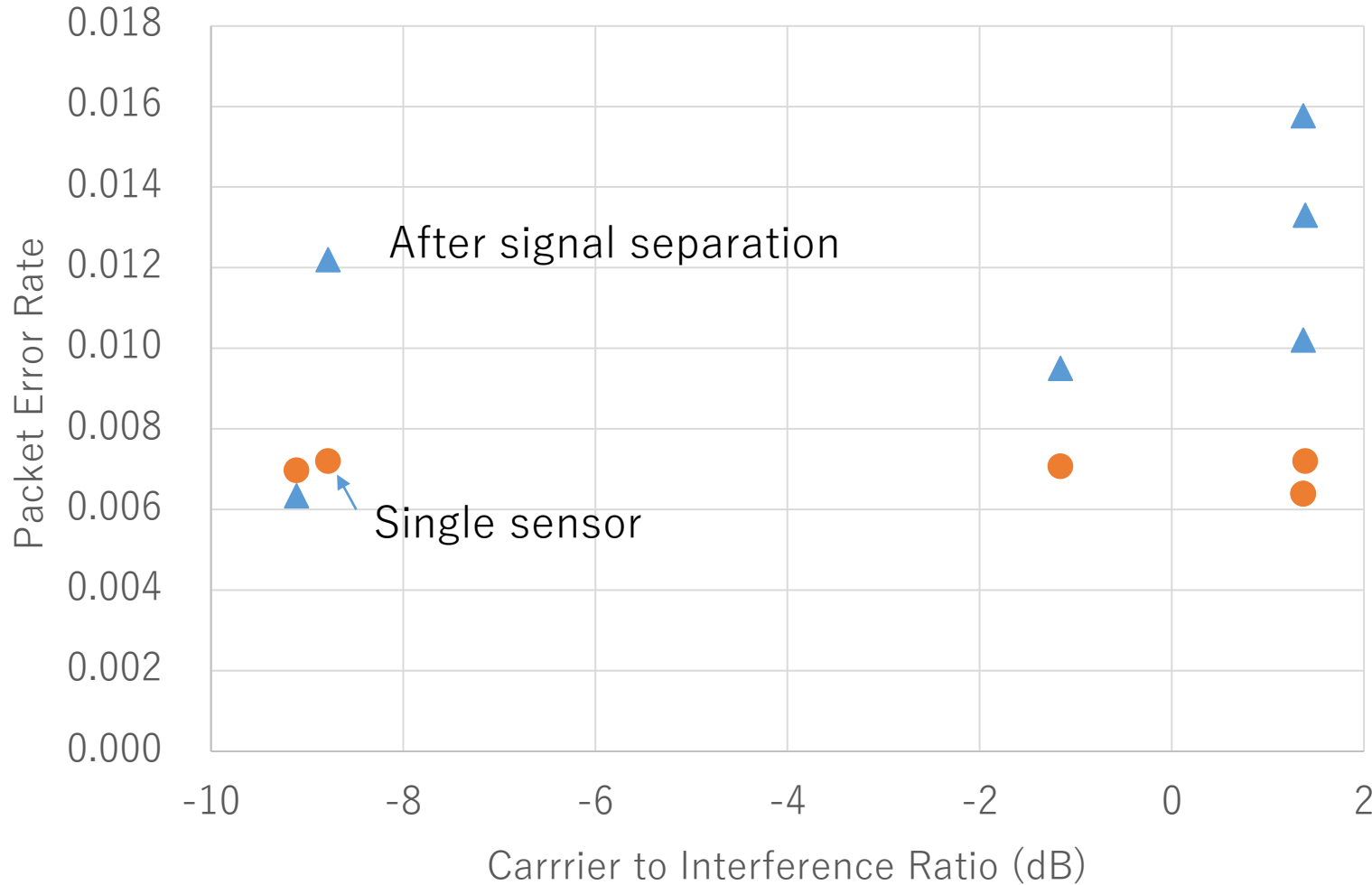


WiSEE2019
Mitsugi, et.al. "Real-time
separation of collided signals in
multiple zones backscatter
communication system"

Single channel signals separation using statistical independence of signals (Fast Independent Component Analysis)



Packet error after signal separation is equivalent to that of single sensor.

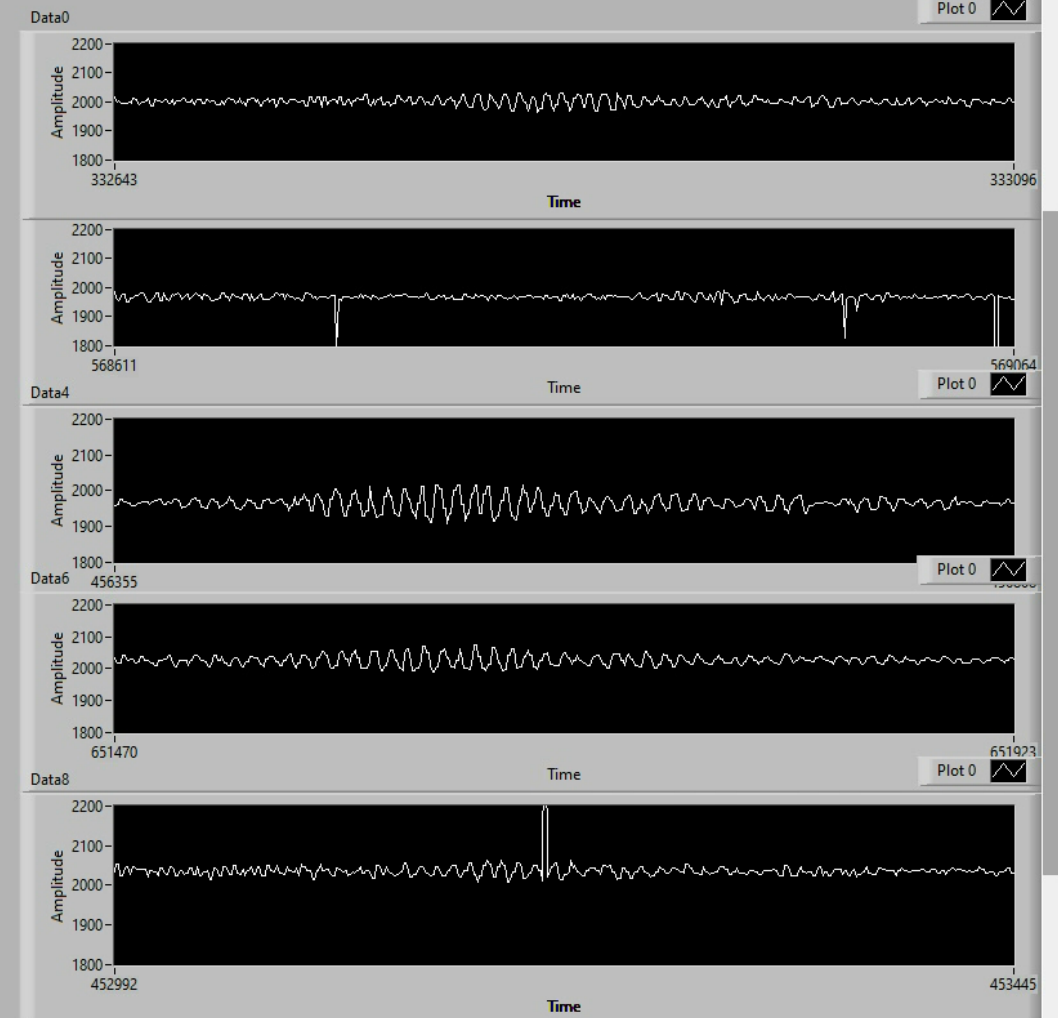
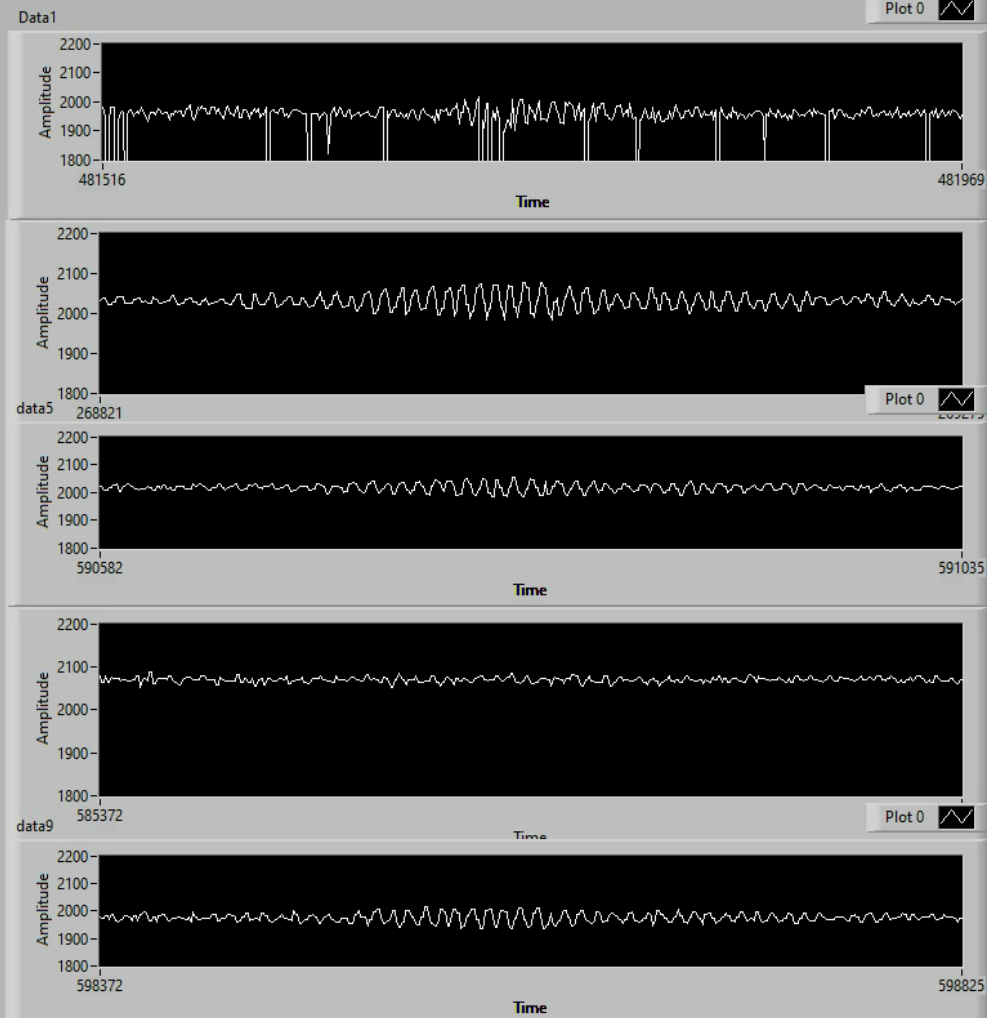


10 signals concurrent streaming with two receiving zones





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Multizones Synchronization Evaluation

