

## Collision Resolution for Robust Coexistence of Multiple Bluetooth Piconets

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With the increasing popularity of wireless networking, multiple networks are likely to coexist in a physical environment. Without coordination among coexisting networks, interference due to frequency collision may greatly decrease the performance. For example, packet error rate can be as high as 20% in a 12-piconet environment [1]. Most existing techniques focus on collision avoidance at the MAC layer, which are not applicable when there are multiple uncoordinated frequency hopping (FH) networks, such as multiple Bluetooth piconets. Recently we developed a signal processing technique that resolves collisions in the physical layer, and recovers data packet without retransmission, thus improving network throughput.

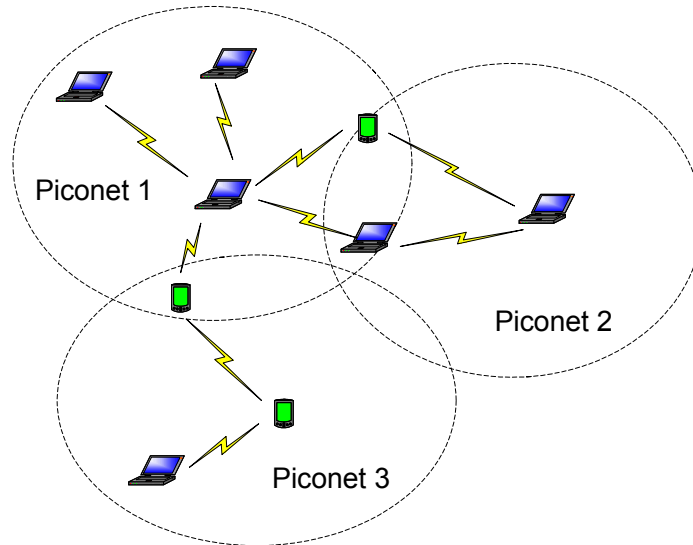


Figure 1: Multiple coexisting Bluetooth piconets.

In this demonstration, a software test bed will be used to show that the collision resolution technique enables robust coexistence of multiple Bluetooth piconets. As illustrated in Figure 1, when multiple Bluetooth piconets are within each other's transmission range, collisions may occur when two or more networks hop into the same frequency. The testbed is developed based on Matlab Simulink environment with a customized graphic user interface. The block diagram of the testbed is shown in Figure 2.

The testbed simulates the data packet transmissions in multiple networks, and calculates real-time frame error rate (FER) and bit error rate (BER) at the receiver end. The improved FER and BER are also shown side-by-side when the collision resolution technique is applied. A built-in Bluetooth voice transmission can also be activated. A device in piconet 1 may receive transmissions from  $N$  piconets. The transmissions are not synchronized across different piconets. The proposed receiver consists of a conventional Bluetooth receiver and a collision resolution unit. Collided data packets

are sent to the collision resolution unit when collisions occur, while successful packets are sent directly to the output. Various parameters can be changed, such as the number of networks, data packet length, signal-to-noise ratio, to simulate difference scenarios. The demo shows that our collision resolution technique works well in low to moderate network traffic loading.

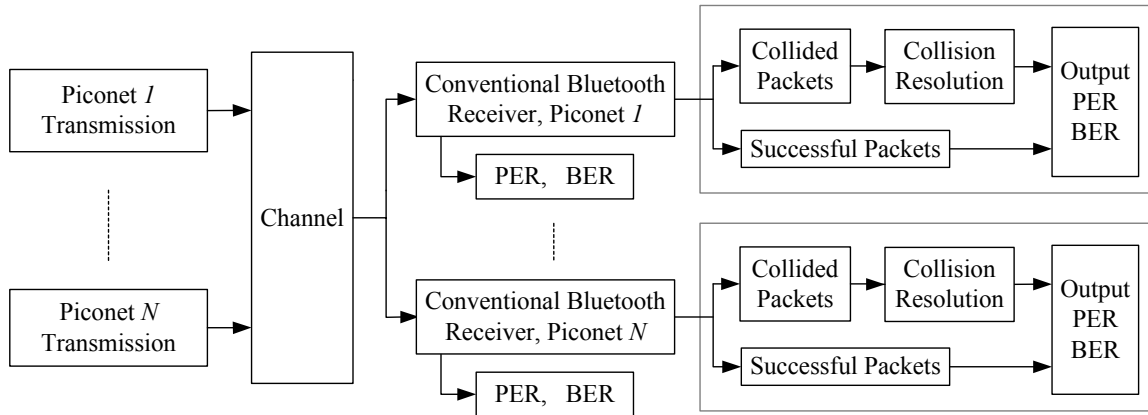


Figure 2: The system block diagram for collision resolution in multiple Bluetooth piconets.

The idea behind our technique is that the received signals of multiple FH transmissions can be modeled as a two dimensional frequency mixture in a hop-free segment, since if cast in matrix form, such a mixture has a Vandermonde structure in the time domain, and the use of a sensor array induces Vandermonde structure in the spatial domain. Efficient 2-D harmonic retrieval algorithms can be used to separate data from multiple transmissions even in the presence of frequency collisions [2]. Furthermore, a low-complexity model change detection algorithm based on the principle of expectation-maximization can be coupled with 2-D harmonic retrieval techniques to identify unknown hop timing. Therefore, data from different transmissions can be separated as collisions are resolved.

## References:

- [1] T. Lin, Y. Liu, and Y. Tseng, "An improved packet collision analysis for multi-Bluetooth piconets considering frequency-hopping guard time effect," *IEEE J. Selected Areas in Communications*, vol.22, pp. 2087–2094, Dec. 2004.
- [2] X. Liu, N. D. Sidiropoulos, and A. Swami, "Joint hop timing and frequency estimation for collision resolution in FH networks," *IEEE Trans. Wireless Communications*, vol. 4, pp. 3063–3074, Nov. 2005.