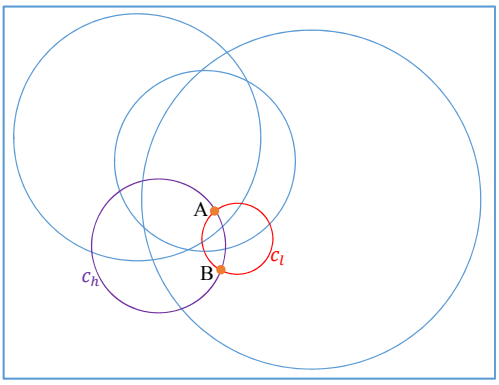
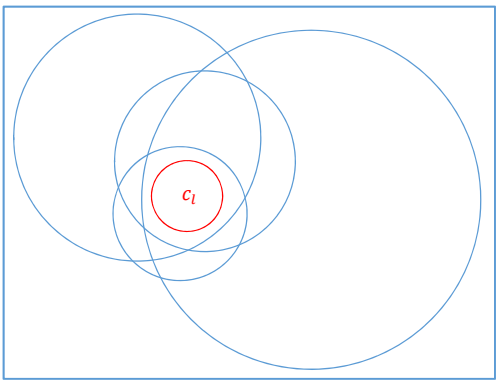
Appendix



a. The circle c_l intersects with c_h at A and B points. A point is contained in all circles but B is not.



b. c_l is fully contained by all circles.

Figure [1]. Examples of the Theorem 1.

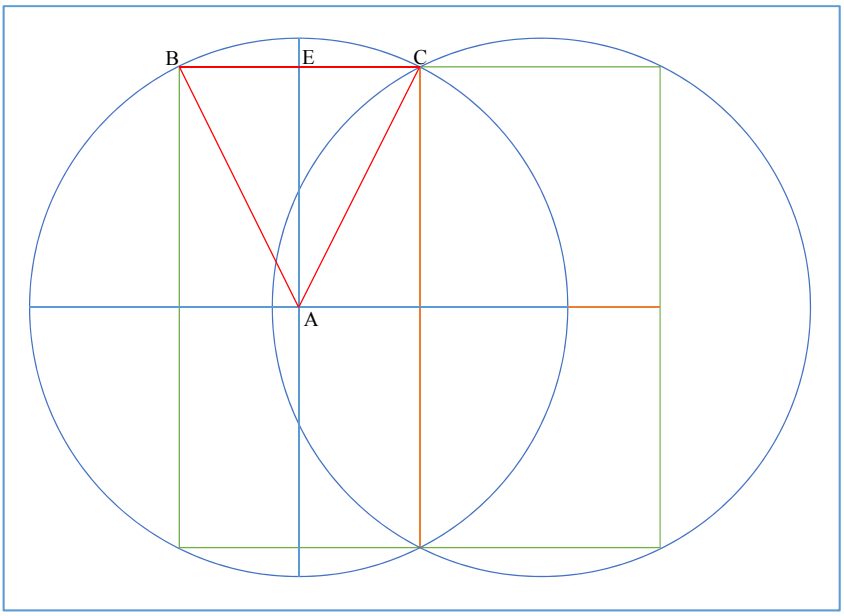


Figure [2]. Two disks cover a square.

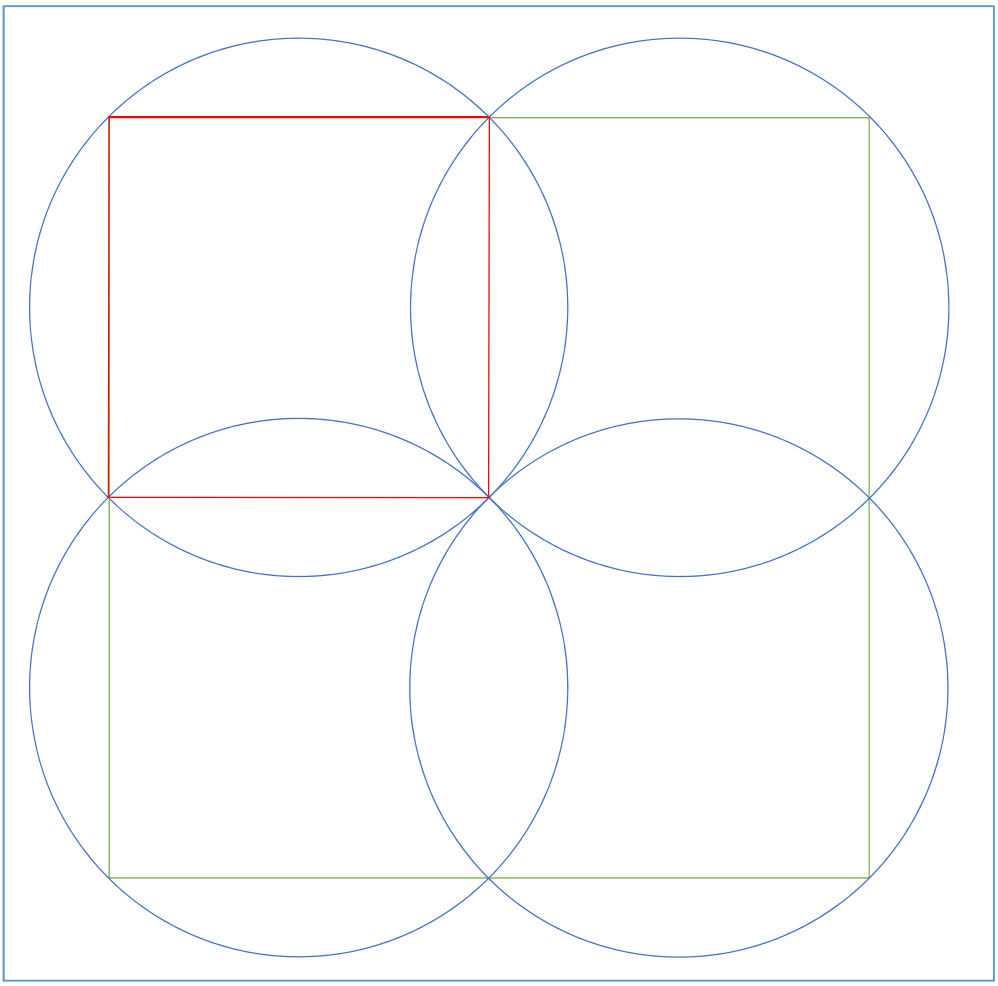


Figure [3]. Four disks cover a square

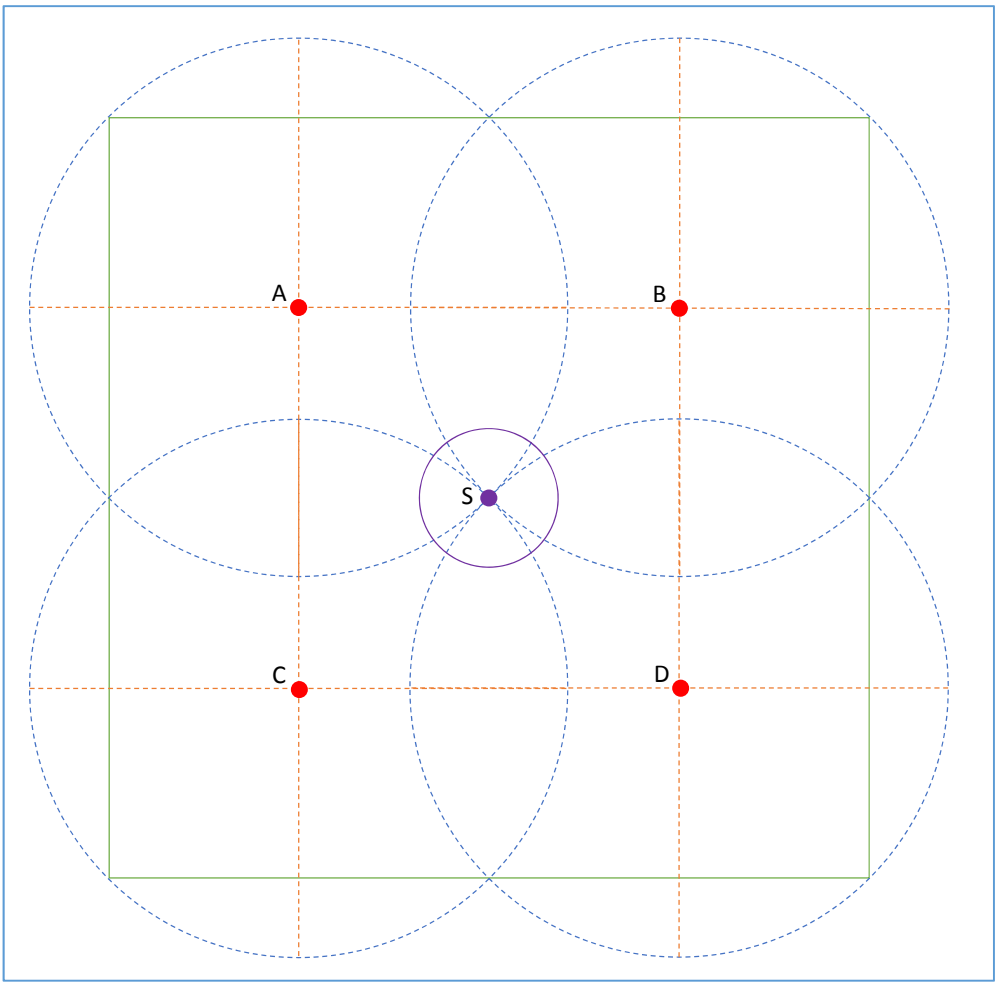


Figure [4]. The sensor node S of radius r_N cannot be covered by either of the four relay nodes, A, B, C or D, even though they can cover all other sensor nodes of radius r_M within the square. (In this example, $l = 1$, which means the square divided by the Shifting Strategy is $2r_M \times 2r_M$. The radius of relay nodes here is equal to r_M, and the green square is larger than $2r_M \times 2r_M$.)

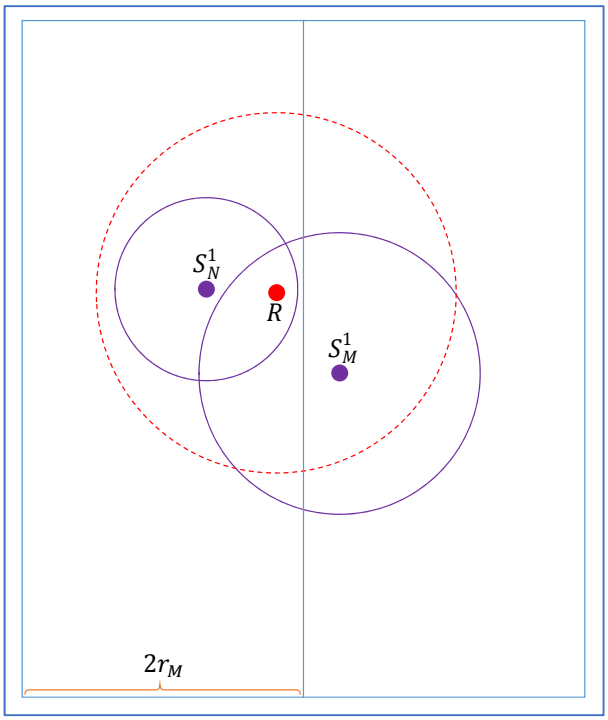


Figure [5]. The relay node R is covering sensor nodes S_M^1 and S_N^1 in two adjacent strips.

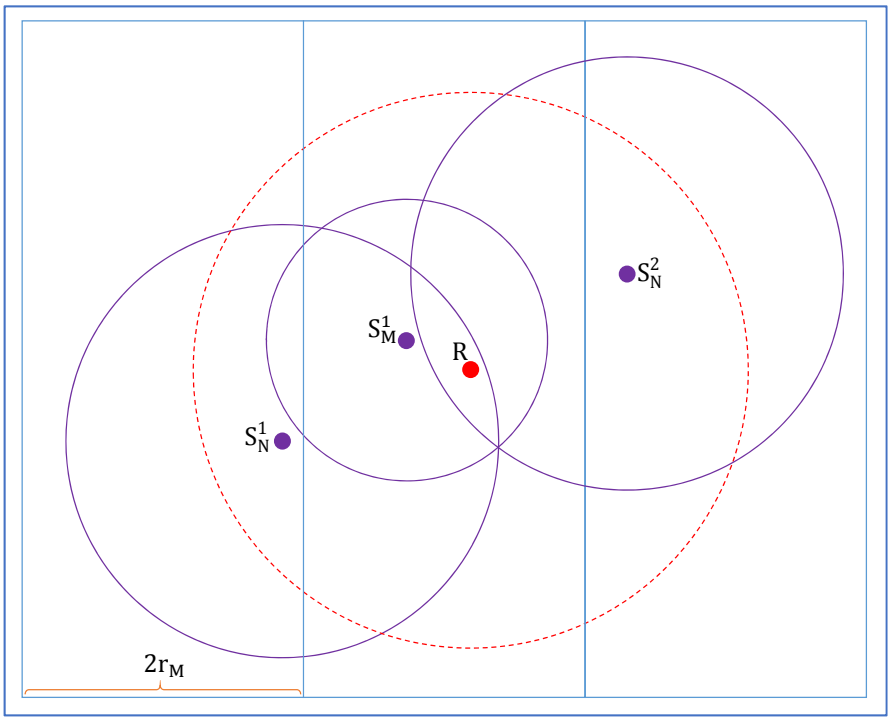


Figure [6]. S_M^1, S_N^1 and S_N^2 in three different strips form an overlap in the middle strip, which makes them be able to be covered by only one relay node.

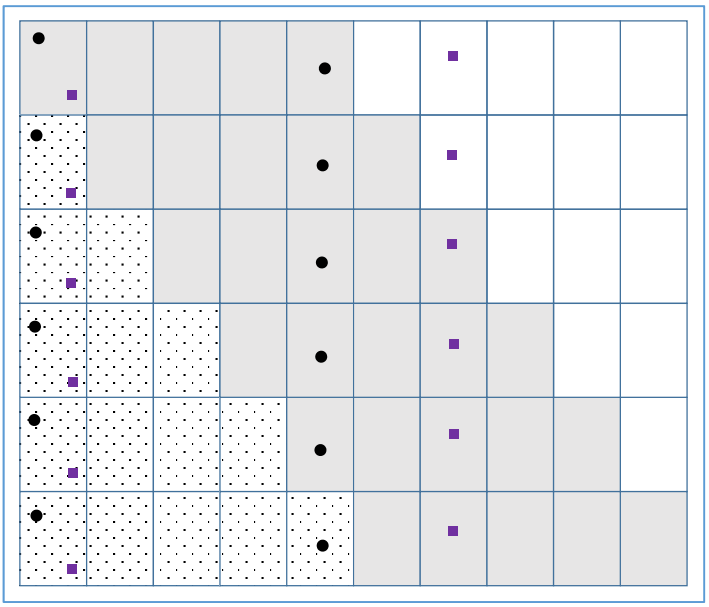


Figure [7]. Each line represents a shift. $l = 5$. The two round dots represent two sensor nodes, and the distance between them is less than $l \cdot D$. We assume they can overlap together. Five shifts are shown above. The last line actually is the same as the first line. It is easy to see that errors occur in all shifts except the first one. The two square dots are also two sensors, but the their distance is greater than $l \cdot D$. We assume they can overlap together as well. It is obvious to see that the error occurs in all shifts.

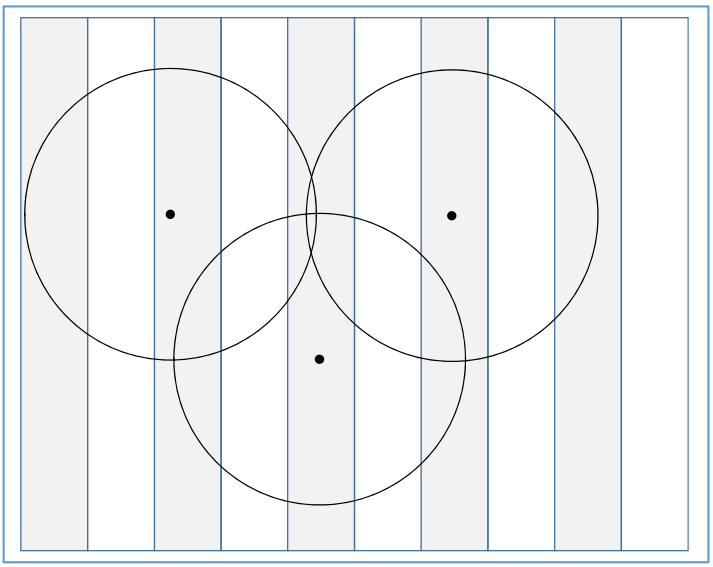


Figure [8]. The Shifting parameter l in this case is 1. Apparently the three sensors overlap together, i.e. they could be covered by only one relay node in the globally optimal solution, but it will have to need three relay nodes in the final result applying the *Shifting Strategy*.

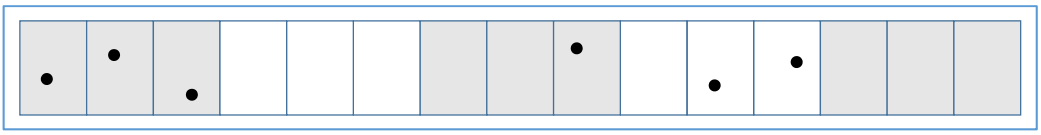


Figure [9]. This example demonstrates an overlap consists of six sensors across four $l \cdot D$ strips, but actually we only need three of them, the first, the third and the fourth ones, to cover this overlap in this shift. It means that errors would only occur in these three strips.