

Affectance-selective Families for Layer Dissemination in IoT

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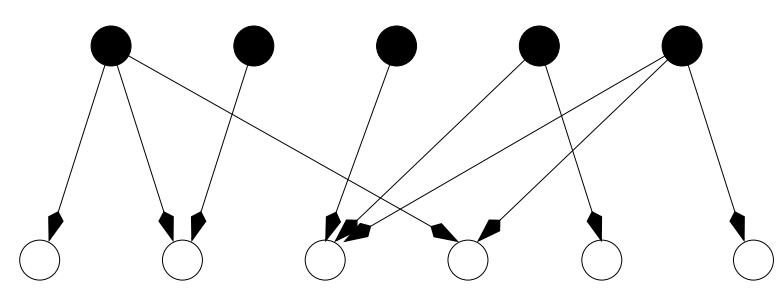
Introduction

To reduce traffic, dissemination protocols for ad-hoc wireless communication networks in IoT subnets often use a **Broadcast Tree**, albeit taking into account the interference of the rest of the links. The bottleneck for fast dissemination in such tree is **how to deliver packets from layer to layer** in a BFS fashion. In this work, we focus on the core challenge of dissemination through one layer of a broadcast tree. We call such problem Layer Dissemination.

Models, Problem & Methods

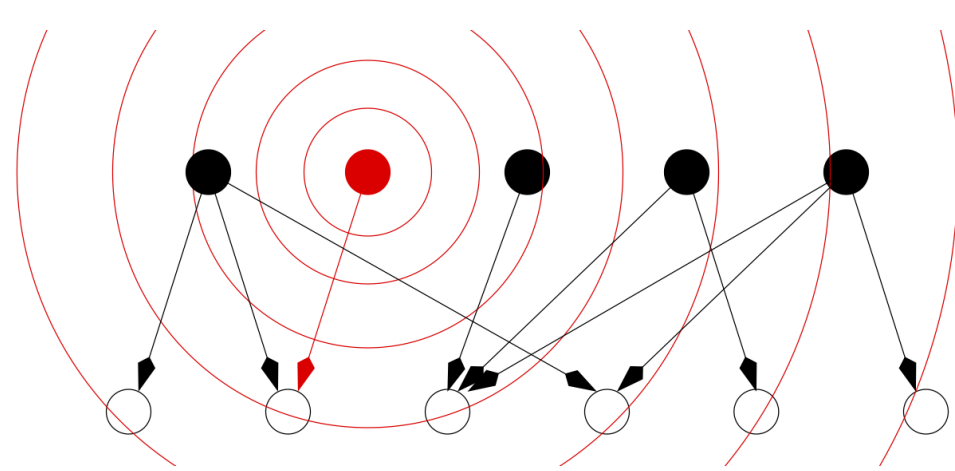
Topology model:

Bipartite graph $G = (V, W, E)$
 V : set of transmitters
 W : set of receivers



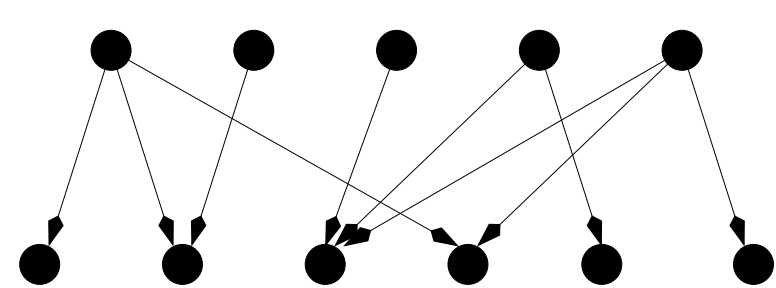
Interference model:

Affectance $[4, 5]$ $0 \leq a(u, (v, w)) \leq 1$:
 interference from transmitter u on link (v, w)



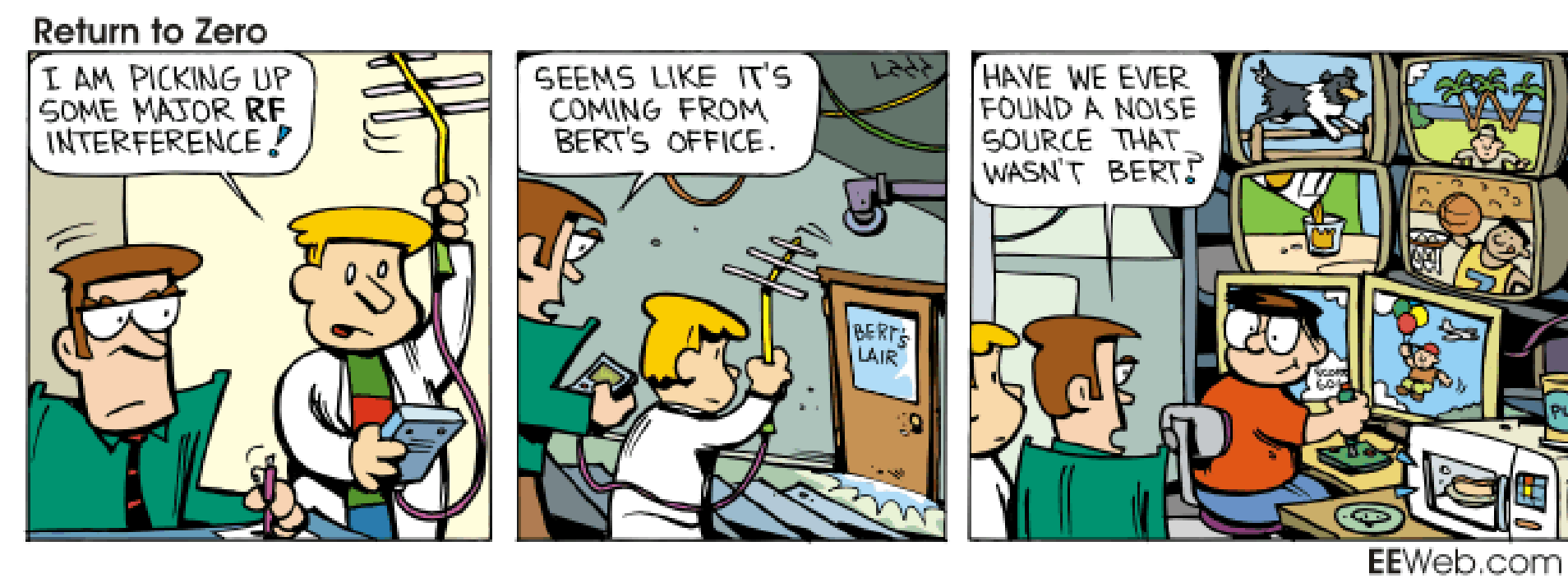
Layer Dissemination problem:

Each receiver in W must receive
 from some transmitter in V



Our approach:

Combines an engineering solution with theoretical guarantees: we provide a method to characterize the network with a global measure of affectance based on measurements of interference in the specific deployment area. Based on this measure, our protocols distributedly produce an ad-hoc transmissions schedule for dissemination. Similar approaches have been explored in practice (e.g. Conflict Maps [6]).



Conclusions

Our experimental results show a striking improvement in performance (cf. Figure 2): the running times of previous protocols grow exponentially with n (the scale of the y axis is logarithmic), whereas our algorithm's running time grows exponentially slower. It can also be seen that our protocol outperforms our theoretical guarantees. All three algorithms are based on iteratively choosing to transmit with some probability. Thus, we conclude that the improvement is due to a careful choice of the transmission probability as a function of the network characterization. Our results expose the importance of studying information dissemination under more accurate models of interference.

Theoretical Results

For a given family $\mathcal{F} = \{F_1, F_2, \dots, F_n\}$ of subsets of integers in $[n]$ modeling the neighbors of each receiver, and a given affectance matrix $A = [a_{u,\ell}]_{u \in V, \ell \in E}$, we show the existence of a family \mathcal{S} of subsets of $[n]$ modeling the transmissions schedule (each subset corresponds to one round of transmissions). **The family \mathcal{S} is affectance-selective on \mathcal{F} and it has size**

$$O(1 + \log n \log \bar{A}),$$

where \bar{A} is the **Maximum Average Affectance**, that is, the following characterization of the network based on \mathcal{F} and A ,

$$\bar{A} = \max_{w \in [n]} \max_{F \subseteq F_w} \sum_{v \in F} \sum_{u \in [n]} a(u, (v, w)) / |F|.$$

We present two $O(1 + \log n \log \bar{A})$ **Layer Dissemination distributed protocols**:

- A randomized protocol (a version of Decay [1]):
 Monte Carlo, very simple, only requires knowledge of n , \bar{A} , and two constants.
- A deterministic protocol (inspired on [2]):
 worst-case guarantees, but nodes need \mathcal{F} and A , exponential computational complexity.

Experimental Results

To evaluate the impact of a more accurate model of interference on Layer Dissemination, we run simulations for a **real-world deployment area**, comparing the performance of our randomized protocol with previous protocols designed for the Radio Network and SINR models.

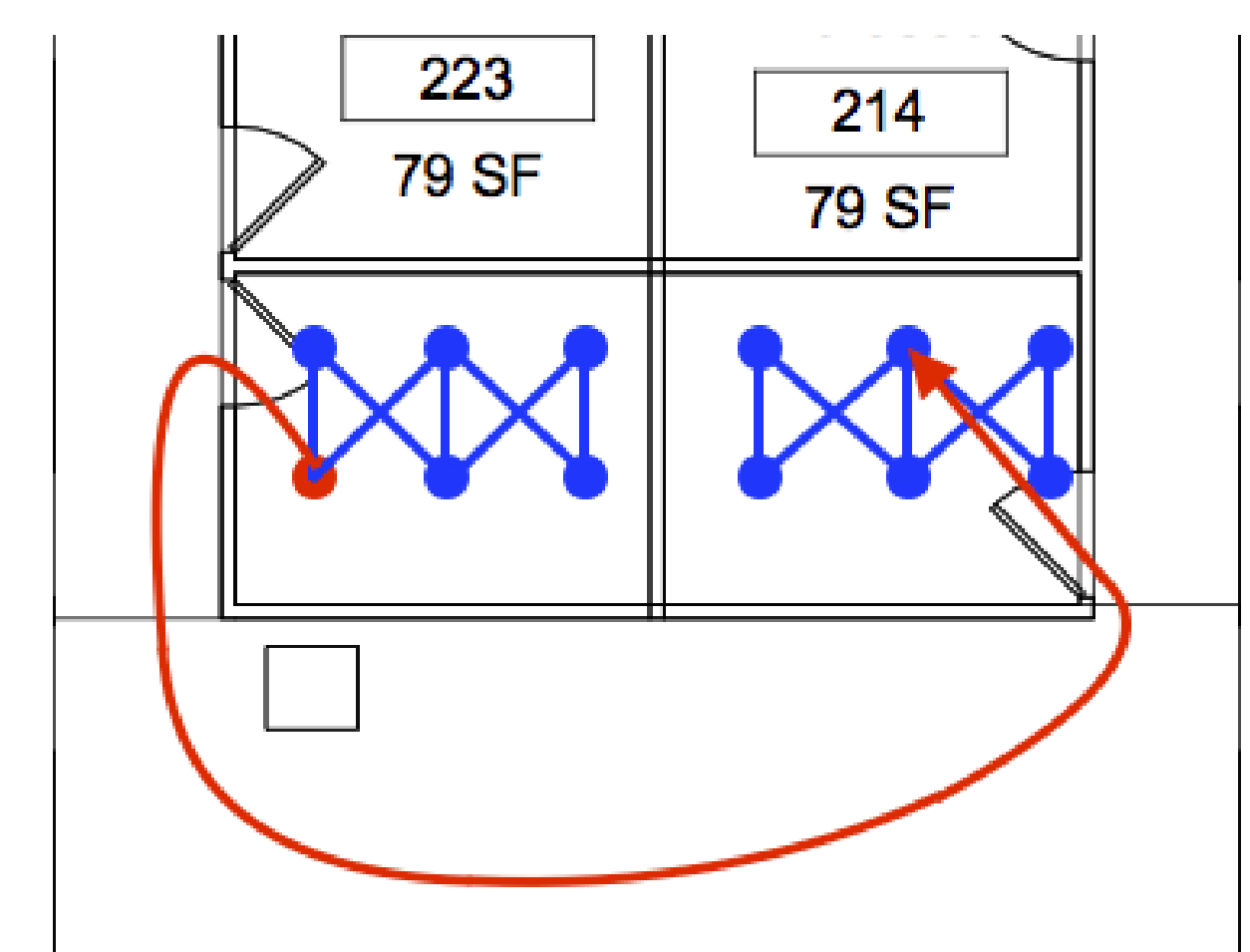


Figure 1: Network deployment area (left). Illustration of affectance (right)

Metallic office walls block millimeter-wave transmissions, most of the propagation is through non-metallic doors. We simulated the Decay [1] protocol for Radio Networks (Δ known), and Algorithm 1 in [3] for SINR (*density* and *dilution* known). For each of the protocols we measured the number of rounds of communication passed until all receivers have received from some transmitter.

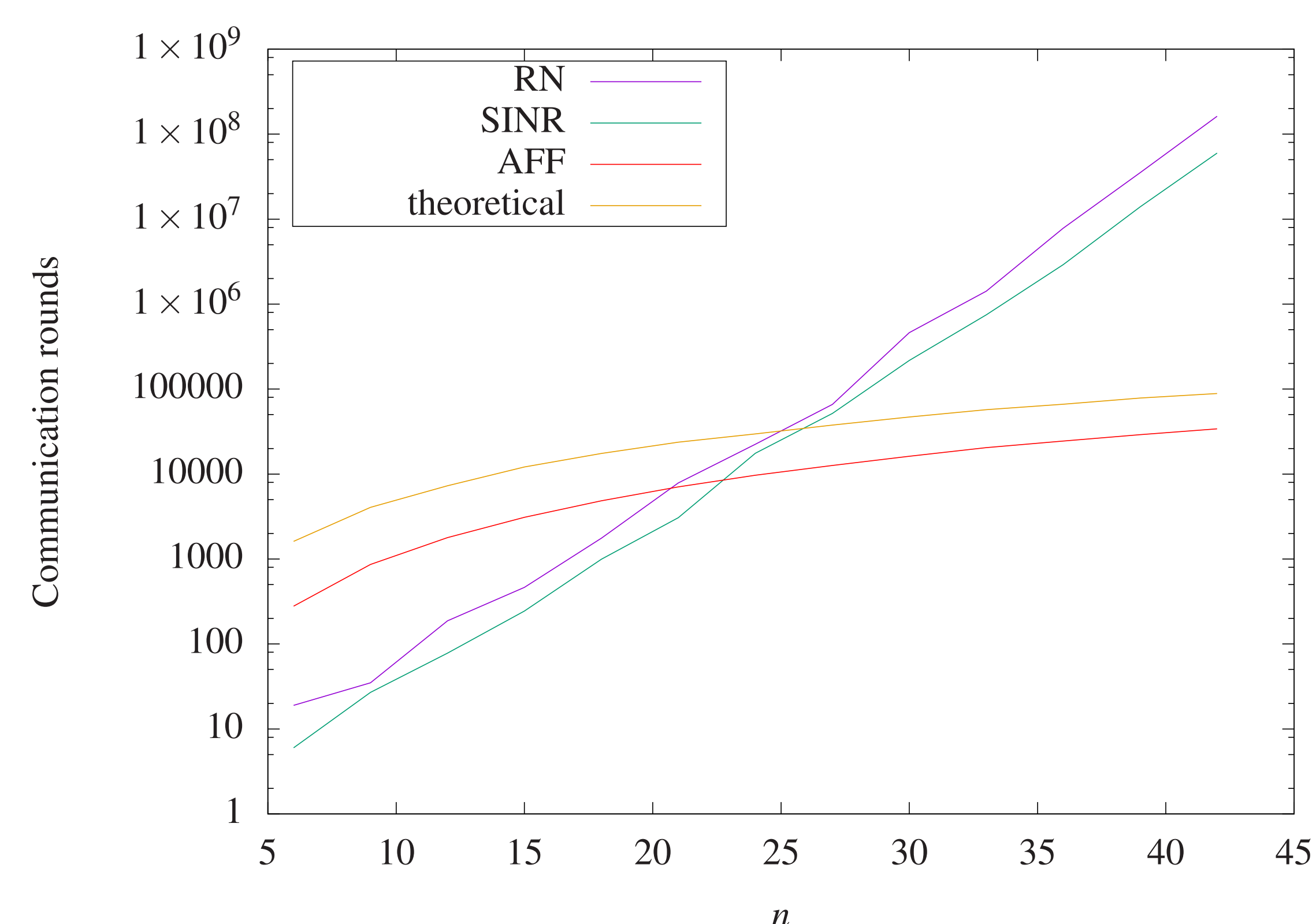


Figure 2: Simulation results.

References

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