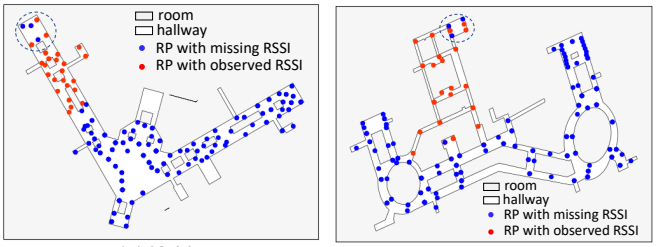
SUPPLEMENTARY MATERIAL TO Data Imputation for Sparse Radio Maps in Indoor Positioning

A. EXAMPLE OF MAR RSSIS AND MNAR RSSIS

As shown in Fig. 1, we selected an AP (access point) in each venue and its deployment location is roughly within the dashed circle. For an RP (reference point), if all fingerprints collected at that RP have observed the selected AP, the RP is marked as red; otherwise, some of its fingerprints have missed the selected AP, and that RP is marked as blue. Clearly, most RPs that are far away from the selected AP are blue, indicating that the selected AP is unobservable at these RPs and the corresponding missing events are classified as Missing Not At Random (MNAR). On the other hand, most of the RPs near the dashed circle are red but there are several blue RPs that sometimes miss the selected AP's signals. The missing events in these RPs are incidental and should be treated as Missing At Random (MAR).



(a) Kaide (b) Wanda

Fig. 1: Observability of a selected AP's signals at different reference points (RPs).

B. BINARIZATION PROCESS

The process of BINARIZATION generates an **AP profile** for each observed RP, as shown in Algorithm 1. It constructs a D-dimensional binary vector $\mathbf{b}_i$ for RP $\mathbf{l}_i$'s fingerprint $\mathbf{f}_i$ such that $\mathbf{b}_i[d] = 1$ if the dth AP is observed at $\mathbf{l}_i$, and $\mathbf{b}_i[d] = 0$, otherwise.

Algorithm 1 BINARIZATION (an RP $\mathbf{l_i}$'s fingerprint $\mathbf{f}_i$)

1: binary vector $\mathbf{b}_i \leftarrow \mathbf{1}^D$
2: **for** $d = 1$ to D **do**
3: **if** $\mathbf{f}_i[d]$ is `null` **then** $\mathbf{b}_i[d] \leftarrow 0$
4: **return** $\mathbf{b}_i$

C. ADDITIONAL EXPERIMENTS ON BLUETOOTH FINGERPRINTING DATA

To gain insights into the effectiveness of our proposals in other application scenarios and indoor venues, we conducted additional experiments using Bluetooth fingerprinting data from a different indoor venue named Longhu[1]. Detailed information of the new venue and the radio map created from the Bluetooth dataset are provided in Table I. Note that the AP here refers to Bluetooth access point instead of Wi-Fi access point.

TABLE I: Statistics of Venues and Created Radio Maps

Venue	Longhu
Floor Area (m^2)	6504.1
RP density (per 100 m^2)	3.11
# of fingerprints	4617
# of RPs	202
# of APs (i.e., # of fingerprint dimension)	330

The APE results for the Bluetooth dataset from Longhu are presented in Table II. We see that *-BiSIM continues to outperform the other data imputation methods with a significant advantage, indicating that the proposed imputation framework is able to generalize to different fingerprinting scenarios.

TABLE II: APE on Bluetooth Data (unit: meter)

	CD	LI	SL	MICE	MF	BRITS	SSGAN	D-BiSIM	T-BiSIM
KNN	22.65	17.99	20.42	57.41	19.57	7.52	6.67	6.28	**5.95**
WKNN	22.76	16.14	18.7	57.27	19.68	7.33	6.74	6.24	**5.86**
RF	23.21	17.69	20.7	63.37	20.36	9.49	8.31	7.13	**6.29**

[1]https://github.com/XLI-2020/BiSIM