Supplementary Material

Optimization of Conventional Bus Routes in Overlapping Bus–Rail Corridors with Urban Rail Transit

Purpose of the supplementary data. This supplementary material provides the aggregated input data used in the simplified simulation experiment. The simulation considers nine candidate bus stations and two terminal metro stations, denoted as A and C. Two stations are considered directly connected only when their distance is no less than 400 m and no greater than 1800 m. A blank entry or "–" indicates that no direct connection is allowed under this connectivity rule, rather than missing data.

Contents. The supplementary tables are organized as follows.

- Table S1 provides the complete distance/connectivity matrix between candidate stations and terminal stations.
- Table S2 provides the complete OD passenger-flow input used in the simulation.
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- Table S4 lists the candidate route adjustment schemes and their evaluation results.
- Table S5 reports the calculation of the 48.69% passenger-time reduction.

In this simplified simulation, the OD passenger-flow input is defined between the nine candidate bus stations and the two terminal metro stations A and C. Therefore, the complete OD passenger-flow input is the 9×2 matrix reported in Table S2.

Table S1. Complete distance/connectivity matrix between candidate stations and terminal stations.

Stations	1	2	3	4	5	6	7	8	9	A	C
1	0	–	510	–	–	–	1740	–	–	535	–
2	–	0	–	400	–	650	1700	–	–	–	800
3	510	–	0	–	980	–	680	–	–	1500	–
4	–	400	–	0	–	–	–	–	–	–	800
5	–	–	980	–	0	–	1320	–	–	–	–
6	–	650	–	–	–	0	–	1000	1800	–	–
7	1740	1700	680	–	1320	–	0	740	–	–	–
8	–	–	–	–	–	1000	740	0	960	–	–
9	–	–	–	–	–	1800	–	960	0	–	–
A	535	–	1500	–	–	–	–	–	–	0	–
C	–	800	–	800	–	–	–	–	–	–	0

Note: "–" indicates that no direct connection is allowed between the corresponding stations under the adopted connectivity rule. The travel time on each feasible segment is calculated from the corresponding distance and the assumed average bus speed of 20 km/h.

Table S2. Complete OD passenger-flow input used in the simulation.

Terminal station	1	2	3	4	5	6	7	8	9
Metro station A	47	10	23	8	10	13	19	38	3
Metro station C	32	40	31	20	2	36	40	21	15

Table S3. Complete existing travel-time input used in the simulation.

Terminal station	1	2	3	4	5	6	7	8	9
Metro station A	5	38	7.5	7	11	15	14	11	12
Metro station C	42	6	29	4.5	21	10.5	23	19	7

Table S4. Candidate route adjustment schemes and evaluation results.

Scheme	Path	Total time (min)	Length (m)	Passenger flow
1	1–3–7–8–6–2	2796.95	4405	350
2	1–3–7–8–6–2–4	3047.71	4805	378
3	1–3–7–2	3224.99	3715	242
4	1–3–7–2–4	3390.70	4115	270
5	1–3–5–7–8–6–2	3428.53	6535	362
6	1–3–7–8–9–6–2	3610.14	6675	368
7	1–7–8–6–2	3620.99	5465	296
8	1–3–5–7–8–6–2–4	3720.60	6935	390
9	1–3–5–7–2–4	3811.34	6245	282
10	1–7–8–6–2–4	3847.72	5865	296
11	1–3–7–8–9–6–2–4	3921.20	7075	368
12	3–7–8–6–2	4020.28	5370	271
13	1–7–2	4029.02	4775	188
14	1–7–2–4	4170.71	5175	216
15	3–7–8–6–2–4	4243.53	5770	299
16	1–3–5–7–8–9–6–2	4266.88	8275	380
17	1–7–8–9–6–2	4275.29	7205	314
18	3–7–2	4444.93	4680	163
19	3–5–7–8–6–2	4509.84	6990	283
20	1–7–8–9–6–2–4	4562.32	7605	342
21	3–7–2–4	4583.14	5080	191
22	1–3–5–7–8–9–6–2–4	4619.26	8675	408
23	3–7–8–9–6–2	4668.44	7130	289
24	3–5–7–2	4682.24	6300	175
25	3–5–7–8–6–2–4	4774.41	7390	311
26	3–5–7–2–4	4861.77	6700	203
27	3–7–8–9–6–2–4	4951.99	7430	317
28	3–5–7–8–9–6–2	5183.16	8750	301
29	3–5–7–8–9–6–2–4	5508.03	9150	329

Table S5. Calculation of the reported 48.69% passenger-time reduction.

Item	Value
Passenger-time cost of the original bus route, C_{ori}	6285.50 min
Selected adjustment scheme	1–3–7–2
Passenger-time cost of the selected scheme, C_{sel}	3224.99 min
Reduction ratio	48.69%

The reduction ratio is calculated as

$$\frac{C_{\mathrm{ori}} - C_{\mathrm{sel}}}{C_{\mathrm{ori}}} \times 100\% = \frac{6285.50 - 3224.99}{6285.50} \times 100\% = 48.69\%.$$