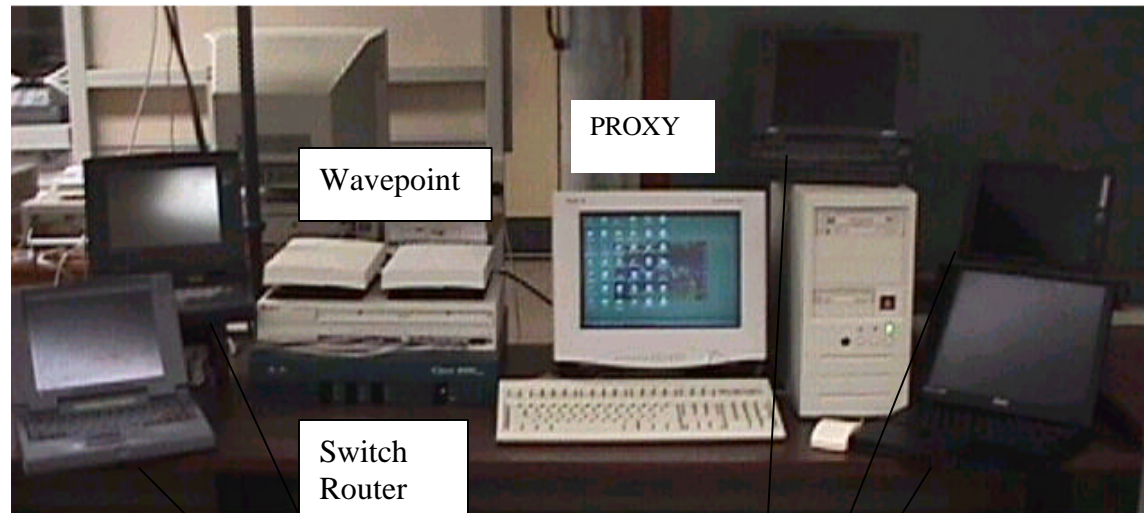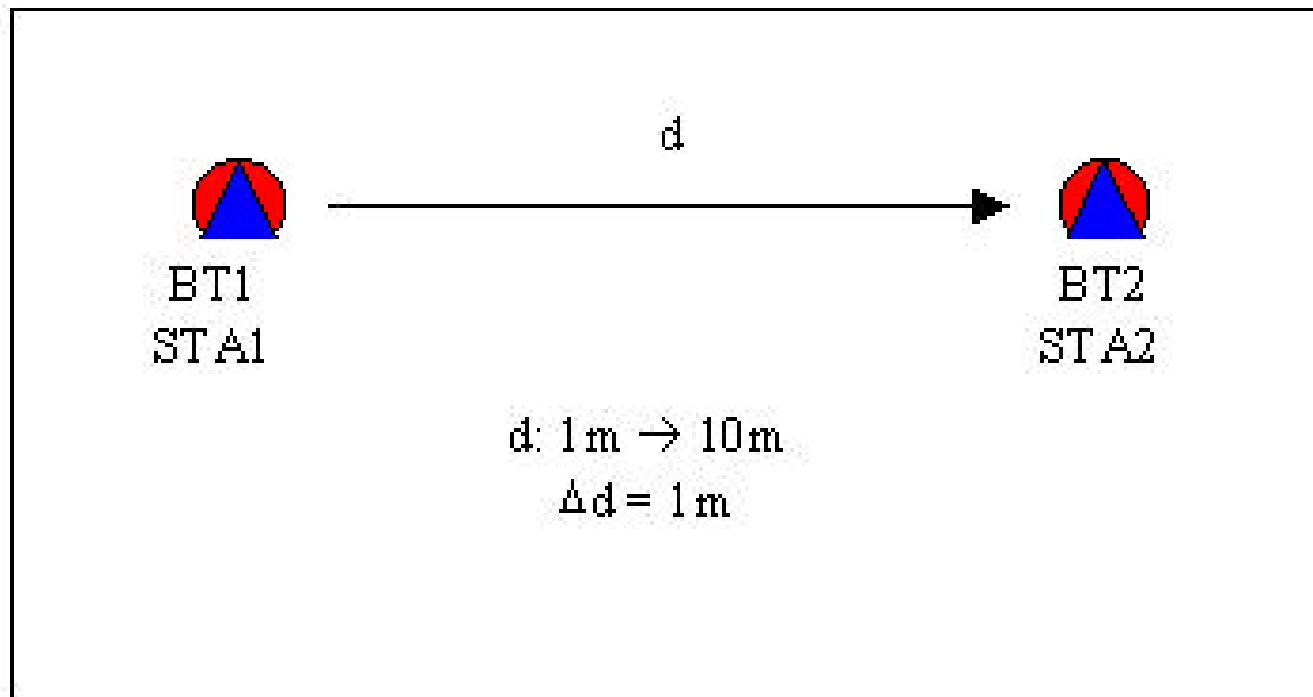# Testbed Equipment

PROXY

Wavepoint

Switch
Router

Laptops with 802.11 and
Bluetooth cards.

CWINS

Scenario 1: open office environment, ad hoc network, Bluetooth and 802.11b usage in one computer

BT1
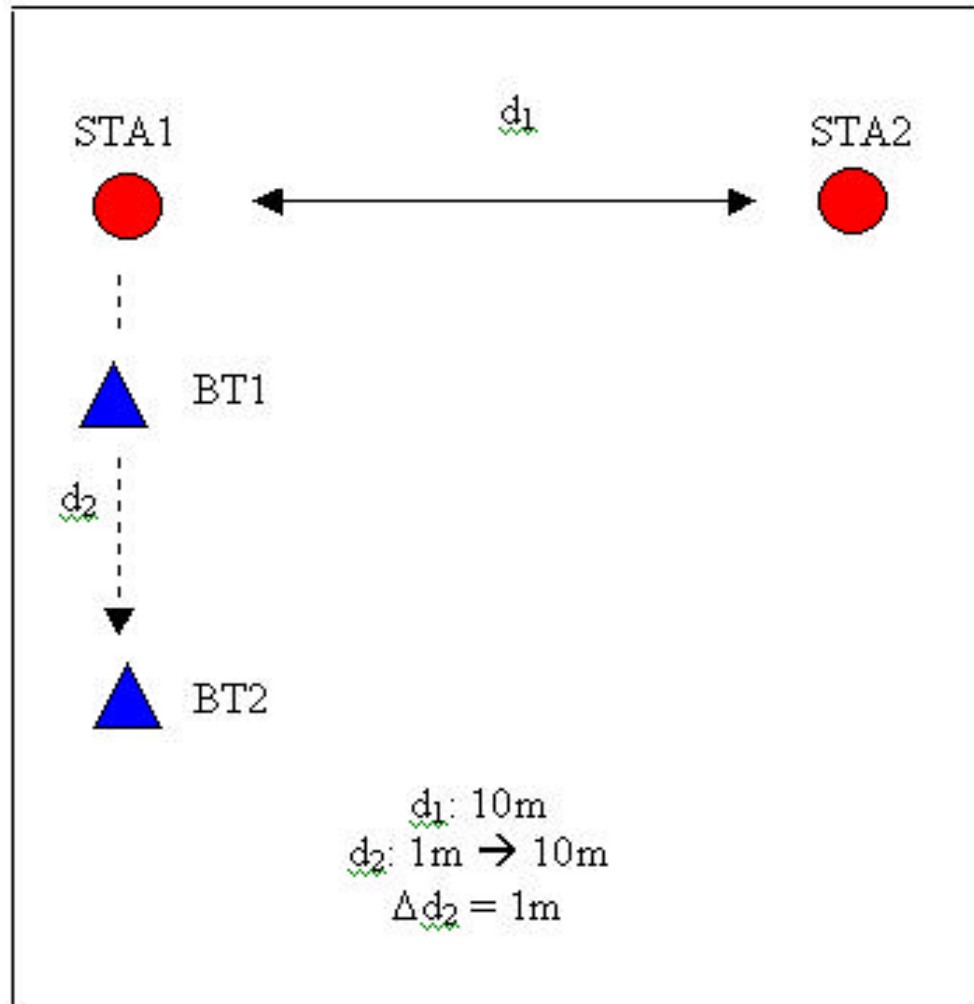STA1

BT2
STA2

d

d: 1m → 10m

Δd = 1m

CWINS

Results: open office environment, ad hoc network, Bluetooth and 802.11b usage in one computer

- IEEE 802.11b radio ping time
  - No Bluetooth interference: Ping = 2.5 ms
  - With Bluetooth interference: Ping = 3.5 ms
- Bluetooth ping times out
- PER for both 802.11b and Bluetooth approaches 100%
- Throughput for both 802.11b and Bluetooth approaches 0 kbps

CWINS

# Scenario 2: Ad hoc network, open office environment, effect of one Bluetooth interferer on 802.11b

Results: Ad hoc network, open office environment, effect of one Bluetooth interferer on 802.11b

Packet Loss Rate of 802.11b in an open office environment ad hoc network: effect of one Bluetooth data interferer on 802.11b DSSS
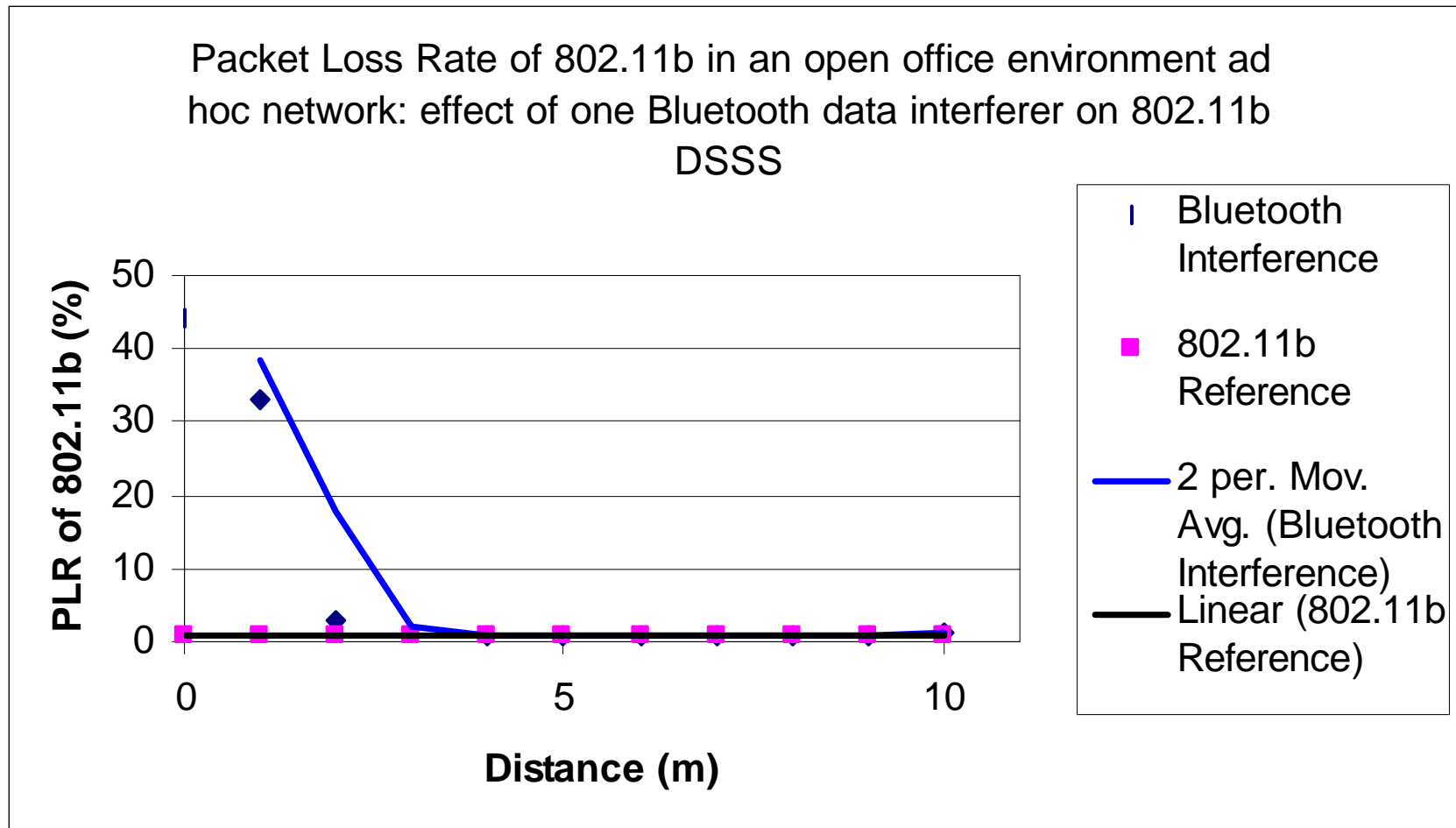
Results: Ad hoc network, open office environment, effect of one Bluetooth interferer on 802.11b
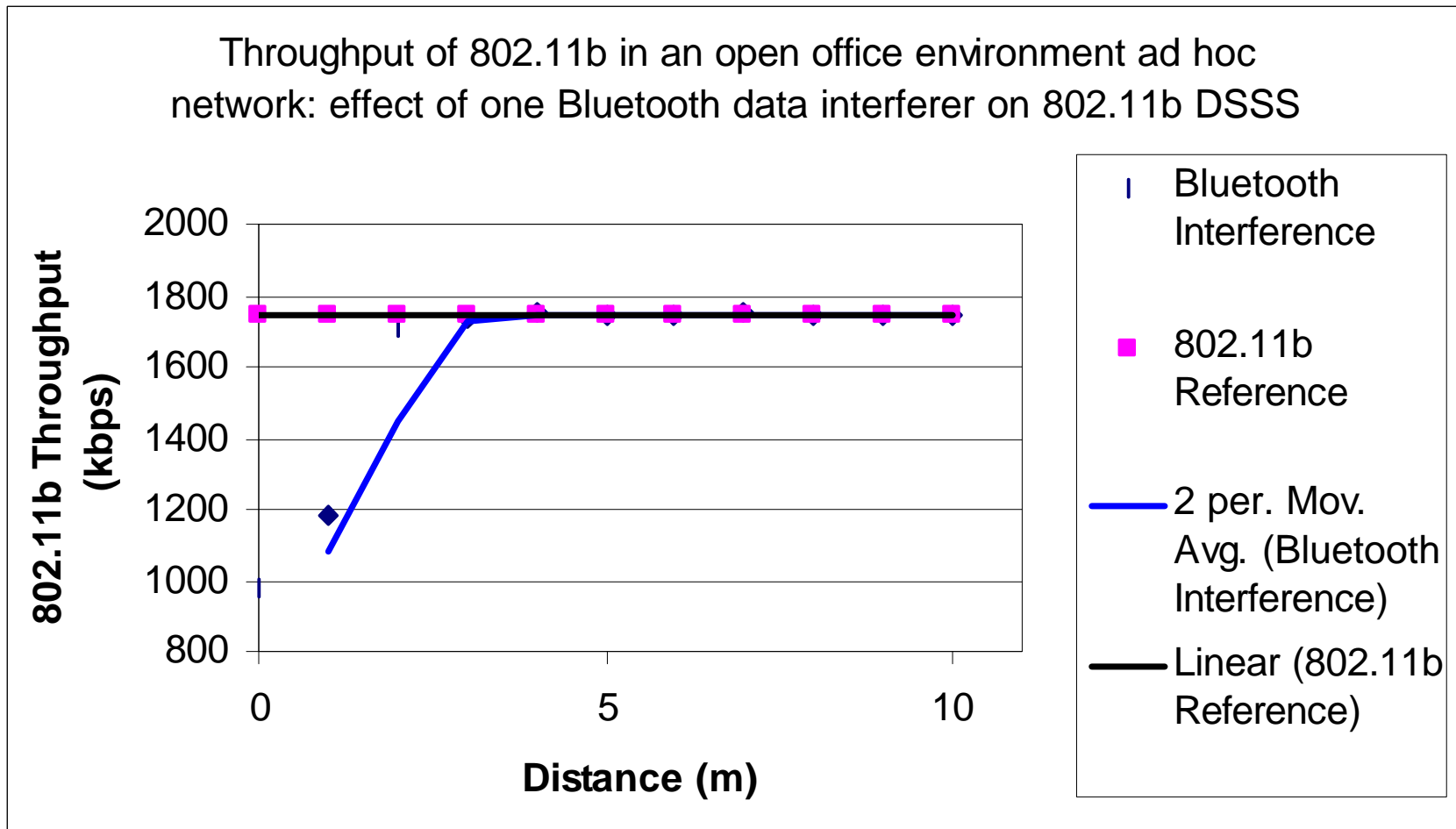
Interference range of Bluetooth into DSSS 802.11b device
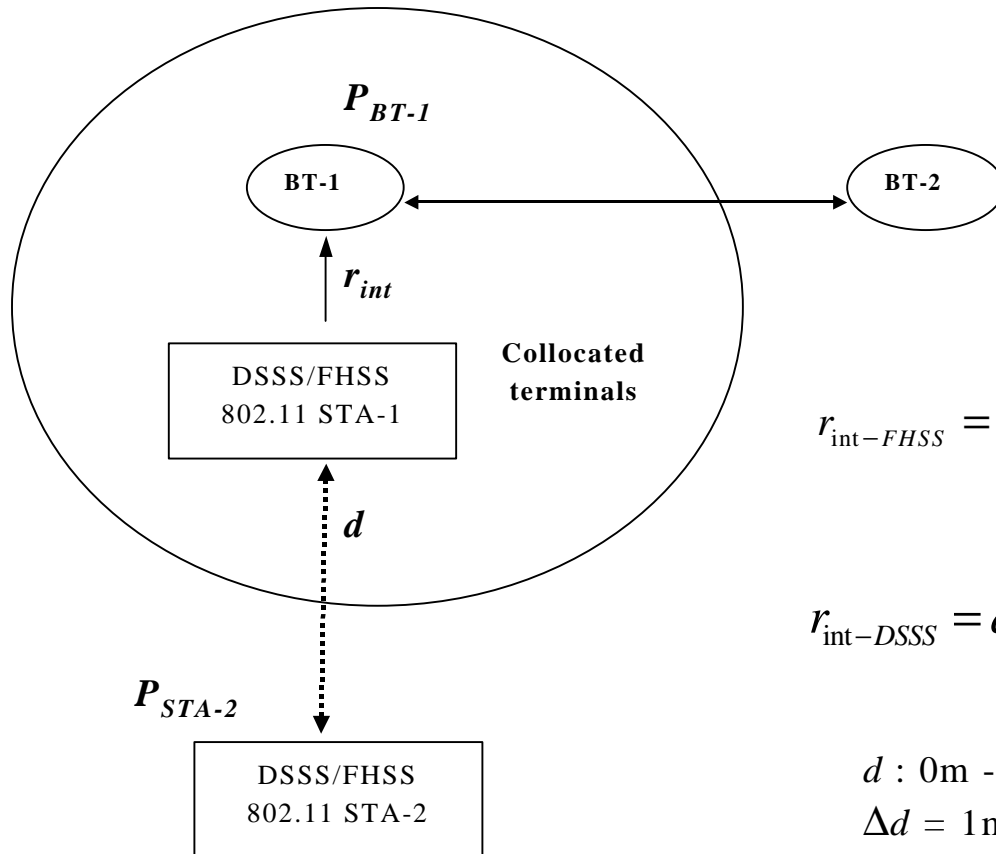
$$r_{int-FHSS} = d \cdot \sqrt[a]{S_{min} \cdot \frac{P_{BT-1}}{P_{STA-2}}} \cdot$$

$$r_{int-DSSS} = d \cdot \sqrt[a]{S_{min} \cdot \frac{P_{BT-1}}{P_{STA-2} \cdot N}} \cdot$$

d : 0m -> 10m

$\Delta d = 1$m

Range of interference between Bluetooth and 802.11

	d	PBT-1	PSTA-2	rint
DSSS	10	1	100	0.95
	10	1	1	9.53
	10	100	100	9.53
	10	100	1	95.35
FHSS	10	1	100	3.16
	10	1	1	31.62
	10	100	100	31.62
	10	100	1	316.23

Assuming open area with a = 2, S_{min} =10 (10 dBm), P_{STA-2} = 100mW (20dBm), P_{BT-1} = 1mW (0 dBm), d = 10m, N = 11

CWINS

Results: Ad hoc network, open office environment, effect of one Bluetooth interferer on 802.11b

■ IEEE 802.11b radio PER and Throughput

– Significant improvement as distance between 802.11b radio and Bluetooth radio is greater than 1 meter

■ DSSS reduces the interference of the narrowband systems for the value of its processing gain.

■ Bluetooth transmitted power seems to have a more adverse effect on the whole network performance.

CWINS

Results: Effect of 2.4 GHz phone on Bluetooth
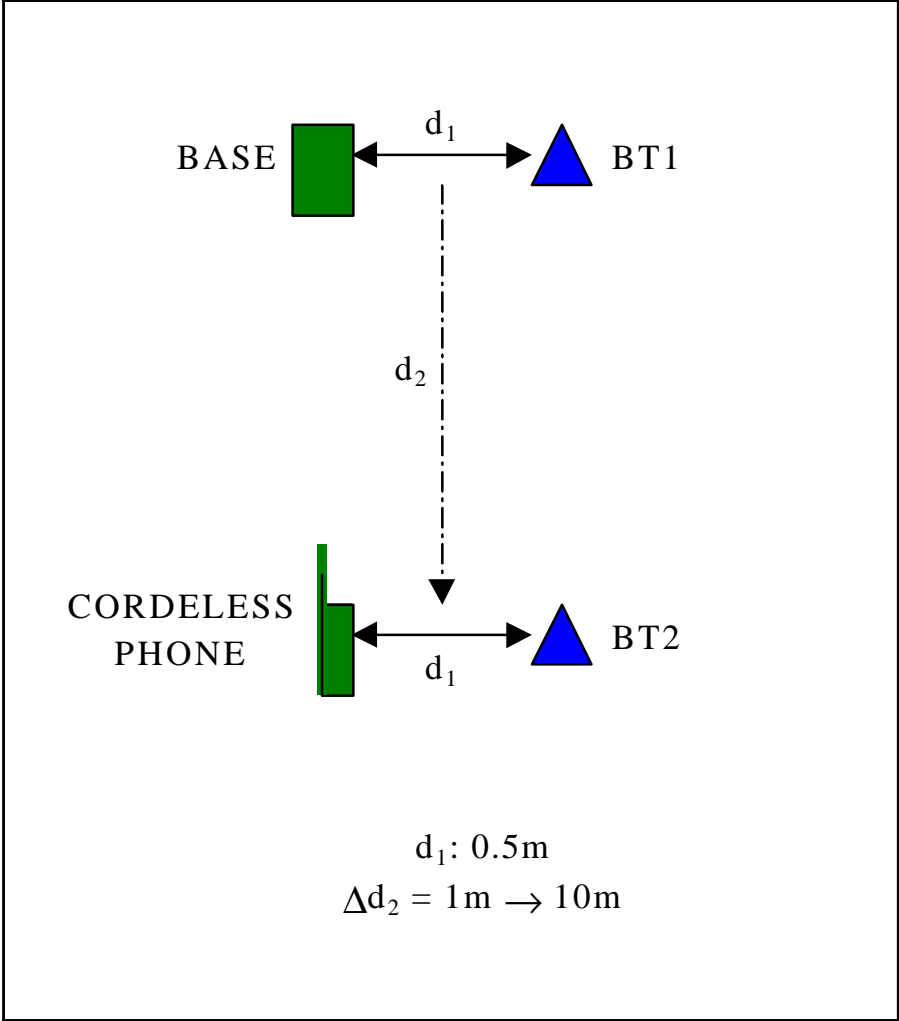
Results: Effect of 2.4 GHz phone on Bluetooth

- **Bluetooth radio PER**
  - Increase in PER from 0% to 10%

- **Bluetooth radio Throughput**
  - Decrease in Throughput from 64 kbps to 60 kbps

- **Similar effects for Bluetooth data**

Conclusions and Recommendations

- Bluetooth and 802.11b DSSS/FHSS cannot be used in the same computer

- Keep Bluetooth and 802.11b DSSS radios at least 1 meter apart for reliable performance

  – The DSSS reduces the interference of the narrowband systems for the value of its processing gain

- Bluetooth can be used near 2.4 GHz phones