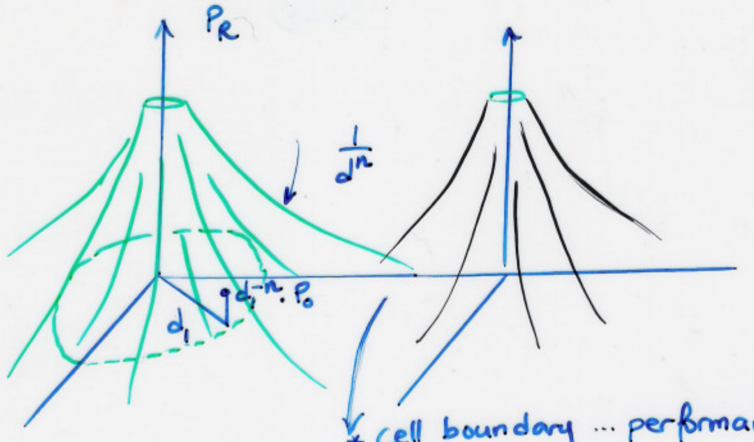
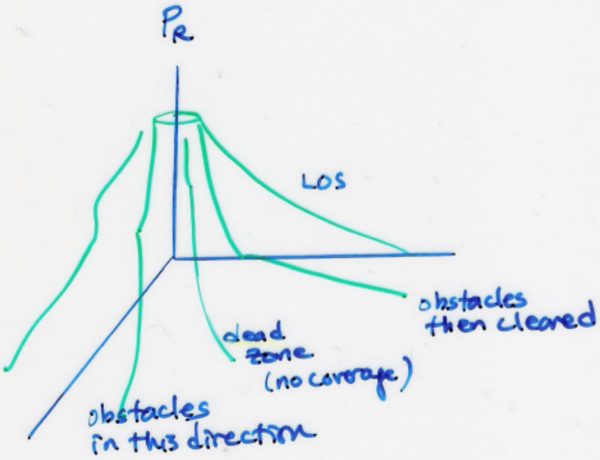


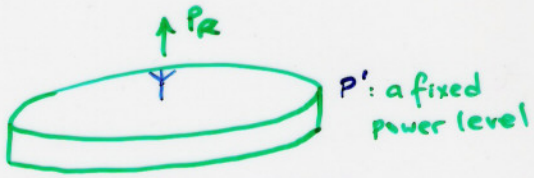
* cell boundary ... performance worst
* the system has to be engineered so that the performance should be satisfactory at the boundaries

→ (1) energy wasted

(2) interference created (especially for low n)



ideal case



1) no energy wasted

2) no intercell interference created

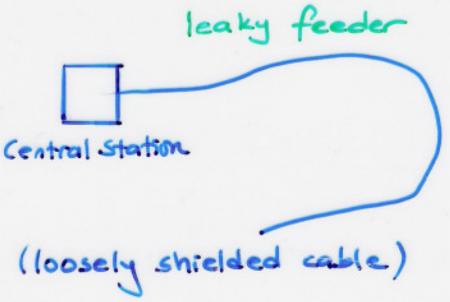
$$P_R = \begin{cases} P', & \text{in the cell} \\ 0, & \text{out of the cell} \end{cases}$$

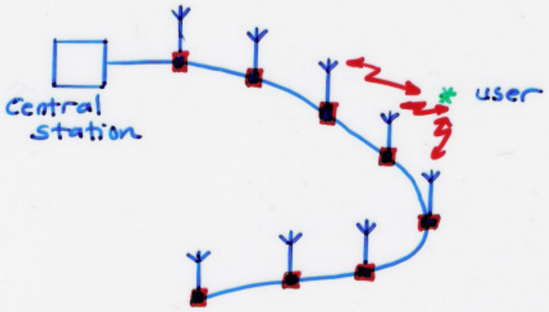
(→ n = 0, then ∞)

* How can you provide good coverage (almost uniform) and conserve energy?

A solution: Distributed Antenna Systems

Distributed Antenna (DA) Systems





* Many omni-directional antennas are coupled to a common feeder.
* No signal-specific processing at the antennas, all the processing is performed at a central station.
* Amplification and frequency up/down conversion at the antennas is inevitable
* No handoff
* Leaky feeder → DA

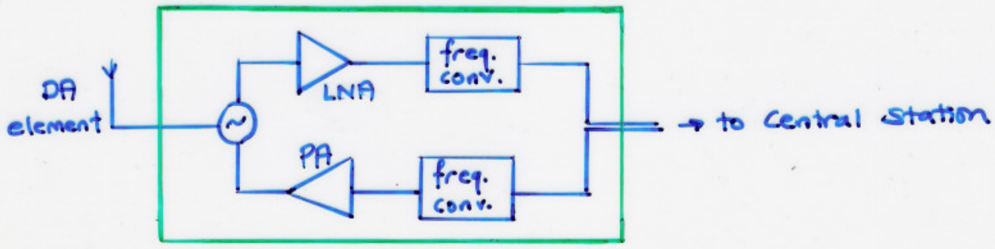
  $\int \rightarrow \Sigma$

* Sub-surface communications (mines, tunnels)

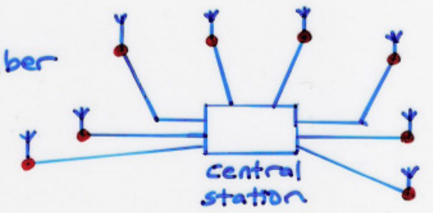
  proposed for indoor cellular comms in late 1980's

  CDMA DA: 1991 by Qualcomm

*



* Radio on fiber



cost effective uniform coverage

Radio Propagation Models

* measurements → emprical model from curve fitting (such as minimize MSE) ← mean square error
* valid for that particular environment and operating frequency
* if environment and/or f_c changes substantially, model has to be validated or updated

∴ difficult task

→ some widely-accepted models emerged

Path-Loss Models

* Free space path-loss:

$$\frac{EIRP}{P_R/G_R} = \left(\frac{4\pi d}{\lambda}\right)^2 = \left(\frac{4\pi d_0}{\lambda}\right)^2\left(\frac{d}{d_0}\right)^2$$

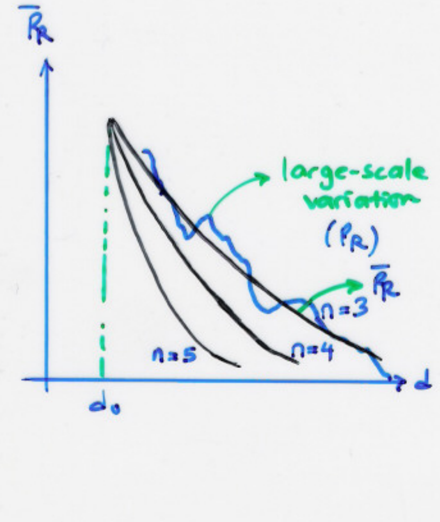
* Mobile radio path-loss:

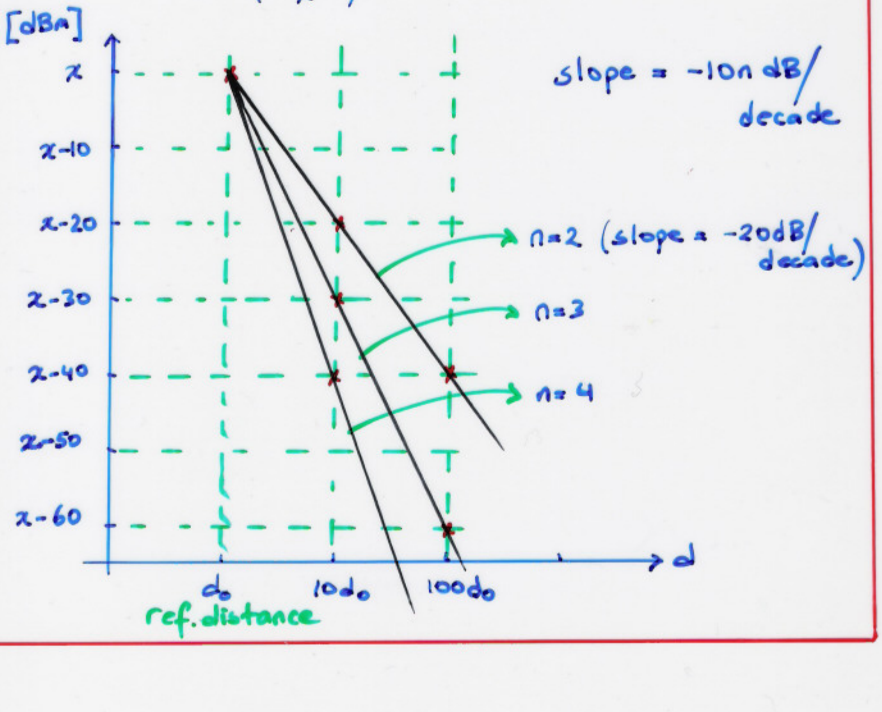
$$\overline{PL}(d) \propto \left(\frac{d}{d_0}\right)^n \qquad \overline{PL}(d) = \left(\frac{4\pi d_0}{\lambda}\right)^2\left(\frac{d}{d_0}\right)^n$$

($\overline{PL}$: average large-scale path-loss)

$$\overline{PL}(d)\,[dB] = \overline{PL}(d_0)\,[dB] + 10\,n\log_{10}\left(\frac{d}{d_0}\right)[dB]$$

$\overline{PL}(d_0)\,[dB]$: reference free-space attenuation : $20\log_{10}\left(\frac{4\pi d_0}{\lambda}\right)$





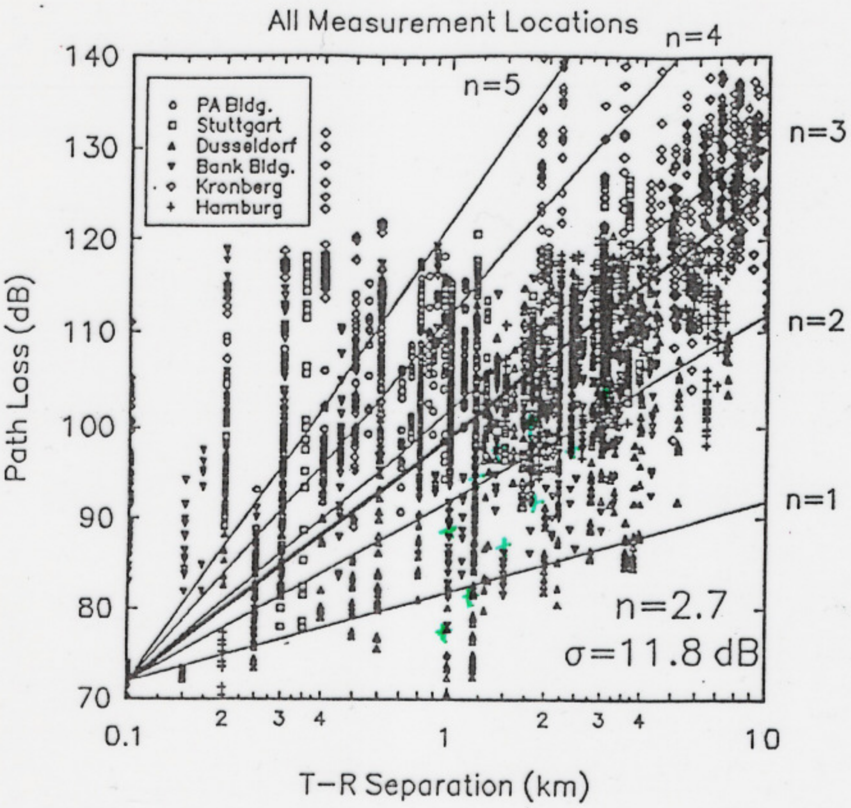


Figure 3.17
Scatter plot of measured data and corresponding MMSE path loss model for many cities in Germany. For this data, $n = 2.7$ and $\sigma = 11.8$ dB [From [Sei91] © IEEE].

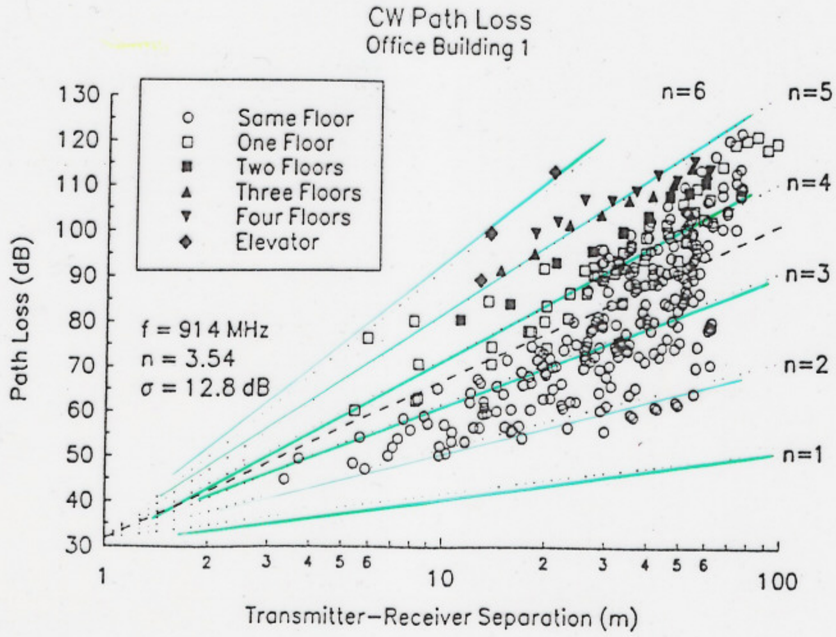


Figure 3.28
Scatter plot of path loss as a function of distance in Office Building 1 [From [Sei92b] © IEEE].