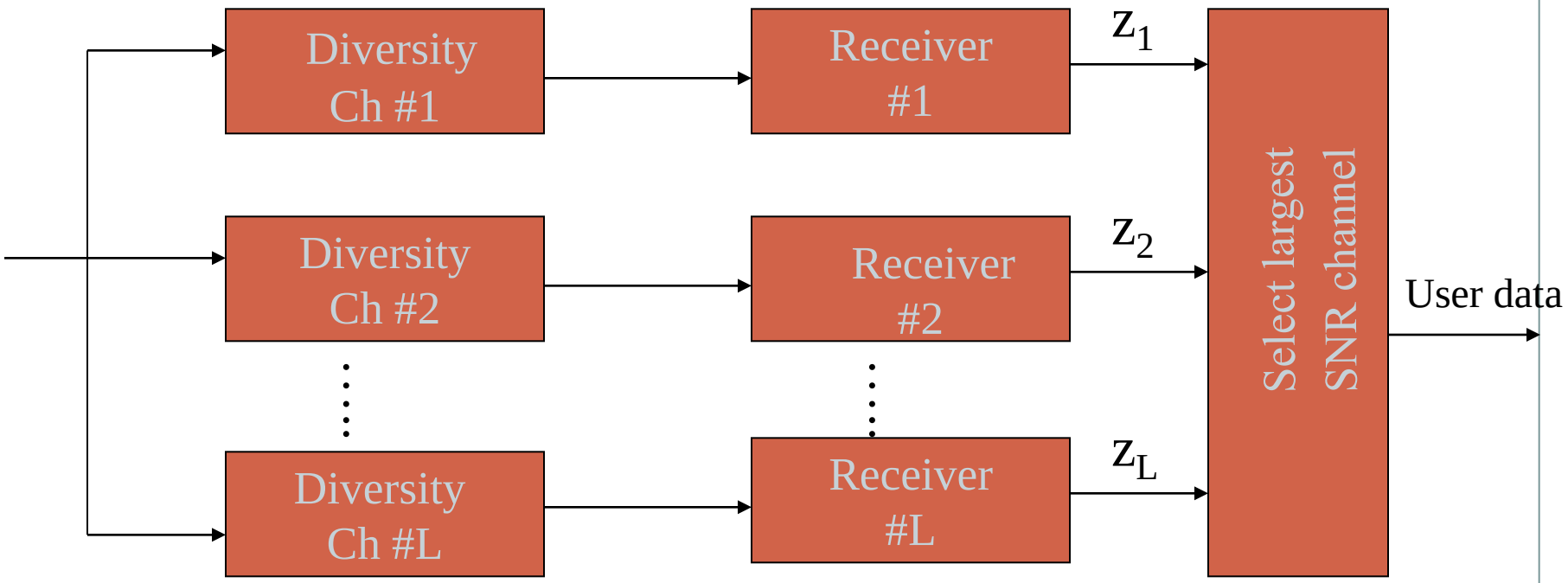
Lecture 20

PRINCIPLES OF SATELLITE COMMUNICATION

Diversity Combining

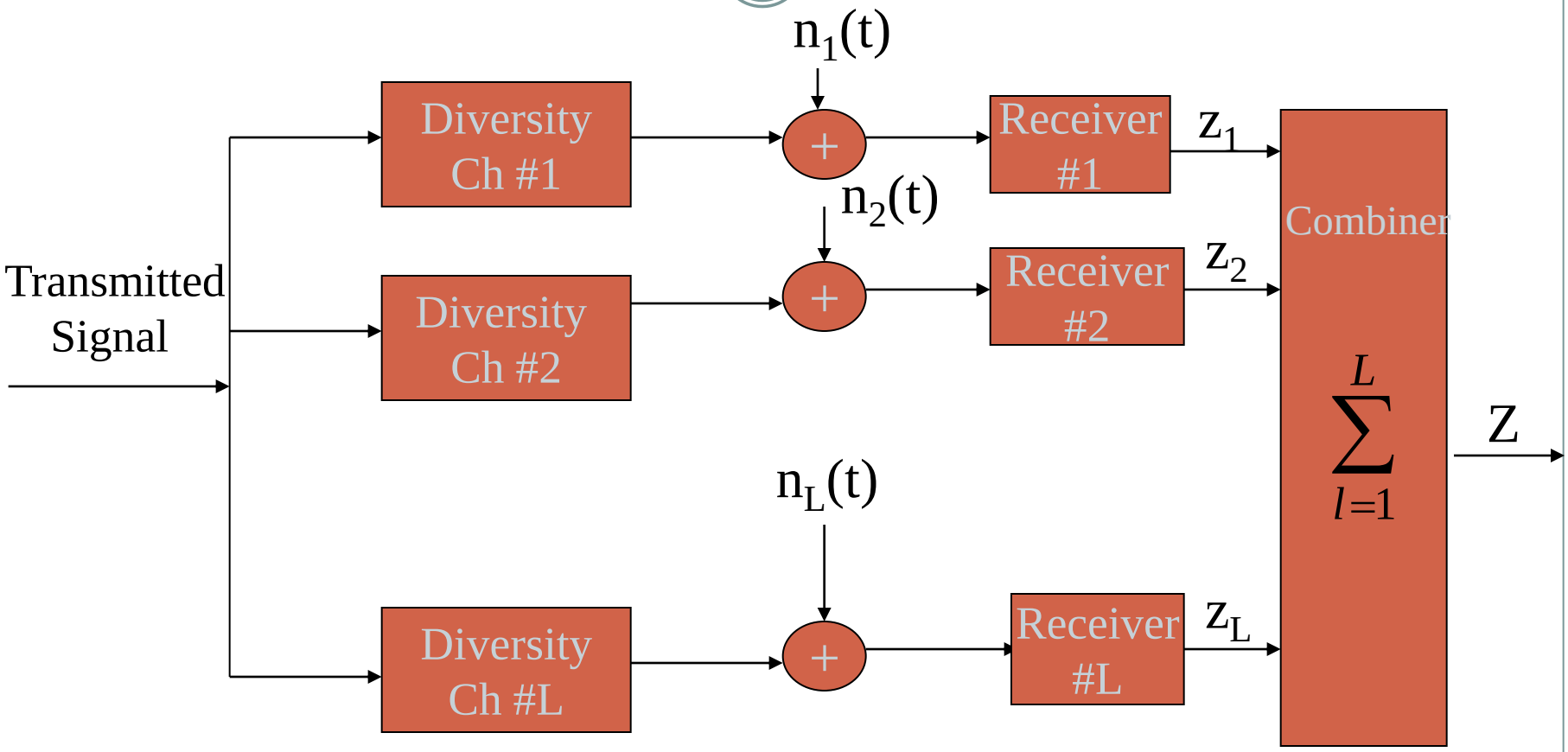
- Selection Diversity (SD)
- Equal Gain Diversity (EGC)
- Maximal Ratio Combining (MRC)
- MRC is an optimal form of diversity
- RAKE receiver in IS-95 is a form of MRC

Selection Diversity Combining



- Channel with the highest SNR is chosen
- (L-1) channel outputs are ignored

Equal Gain Combining (EGC)



- Symbol decision statistics are combined with equal gains to obtain overall decision statistics.

Maximal Ratio Combining(MRC)

- Similar to EGC – decision statistics are summed or combined
- In EGC – each channel is multiplied by equal gain
- In MRC – each channel is multiplied by gain proportional to the square root of SNR of the channel

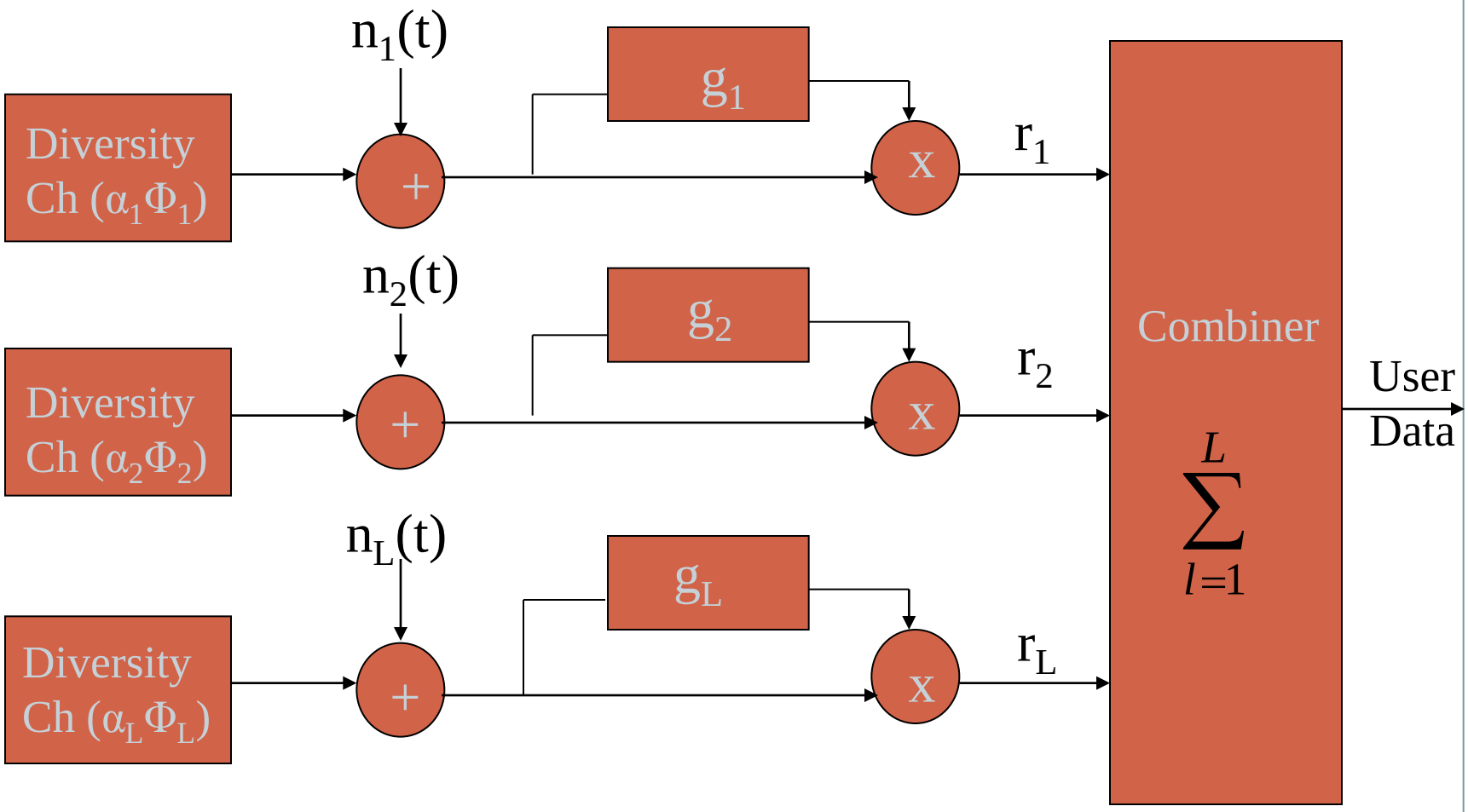
$$g_i \propto \sqrt{SNR}_i$$

- This gives optimal combining

$$\text{Output SNR} = \sum_{i=1}^{L} (SNR)_i$$

- Requires knowledge of SNR of each channel as well as phase of the diversity signal

MRC


$n_1(t)$
Diversity Ch ($\alpha_1\Phi_1$)
+
g_1
x
r_1
$n_2(t)$
Diversity Ch ($\alpha_2\Phi_2$)
+
g_2
x
r_2
$n_L(t)$
Diversity Ch ($\alpha_L\Phi_L$)
+
g_L
x
r_L
Combiner
$\sum_{l=1}^{L}$
User Data

RAKE Receiver Concept

- Multi-path diversity channels
- Problem
  - to isolate various multi-path signals
    - How to do this ?
- If the maximal delay spread (due to multi-path) is T_m seconds and if the chip rate

$$\frac{1}{T_c} = W >> \frac{1}{T_m}$$

  then individual multi-path signal components can be isolated
- Amplitudes and phases of the multi-path components are found by correlating the received waveform with delayed versions of the signal
- Multi-path with delays less than $1/T_c$ can't be resolved

RAKE Receiver Concept

$$m(t) = C(t)\cos(w_0 t)$$

$c(t)$ is a PN Sequence

$$= E\{c(t)\cos(w_0 t)c(t+\tau)\cos(w_0 t+\tau)\}$$

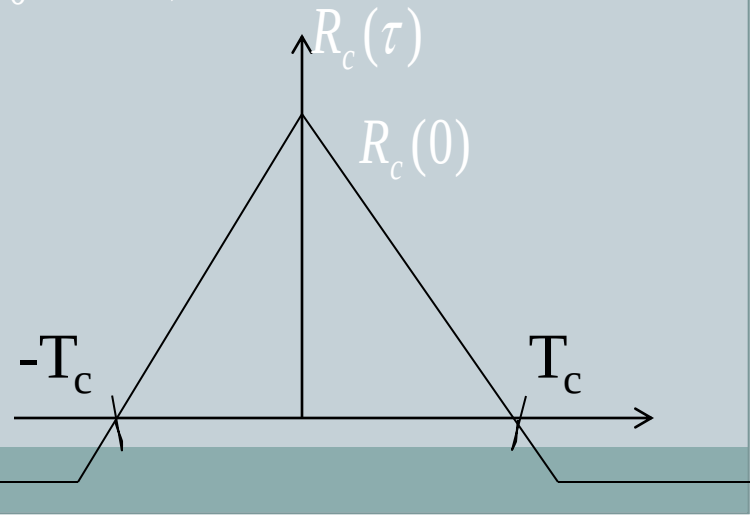
$$R_m(\tau) = E\{m(t)m(t+\tau)\}$$

$$= E\{c(t)c(t+\tau)\}E\{\cos w_0 t \cos(w_0 t+\tau)\}$$

$$= R_c(\tau)\frac{1}{2}\cos(w_0\tau)$$

$$R_c(\tau) \approx R_c(0)[1-\frac{|\tau|}{T_c}] \quad |\tau| < T_c$$

$$\frac{1}{T_c} = w$$



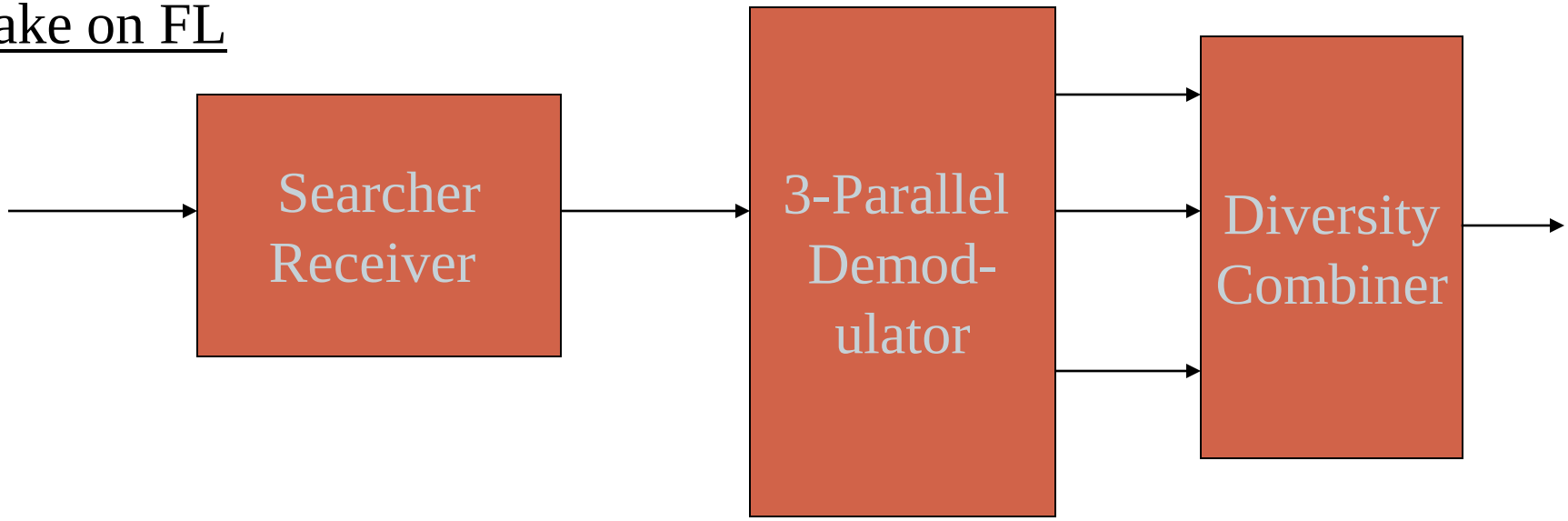
Rake Receiver in IS-95

- Rake Receiver is used in Mobile receiver for combining
  - Multi-path components
  - Signal from different base stations (resolve multi-path signals and different base station signals)
- 3 Parallel Demodulator (RAKE Fingers)
  - For tracking and isolating particular multi-path components (up to 3 different multi-path signals on FL)
- 1 Searcher
  - Searches and estimates signal strength of
    - multi-path pilot signals from same cell site
    - pilot signals from other cell sites
  - Does hypothesis testing and provides coarse timing estimation

Rake Receiver (contd…)

–Search receiver indicates where in time the strongest replicas of the signal can be found

Rake on FL



(Mobile Station Rake Receiver)

Handoff in CDMA System

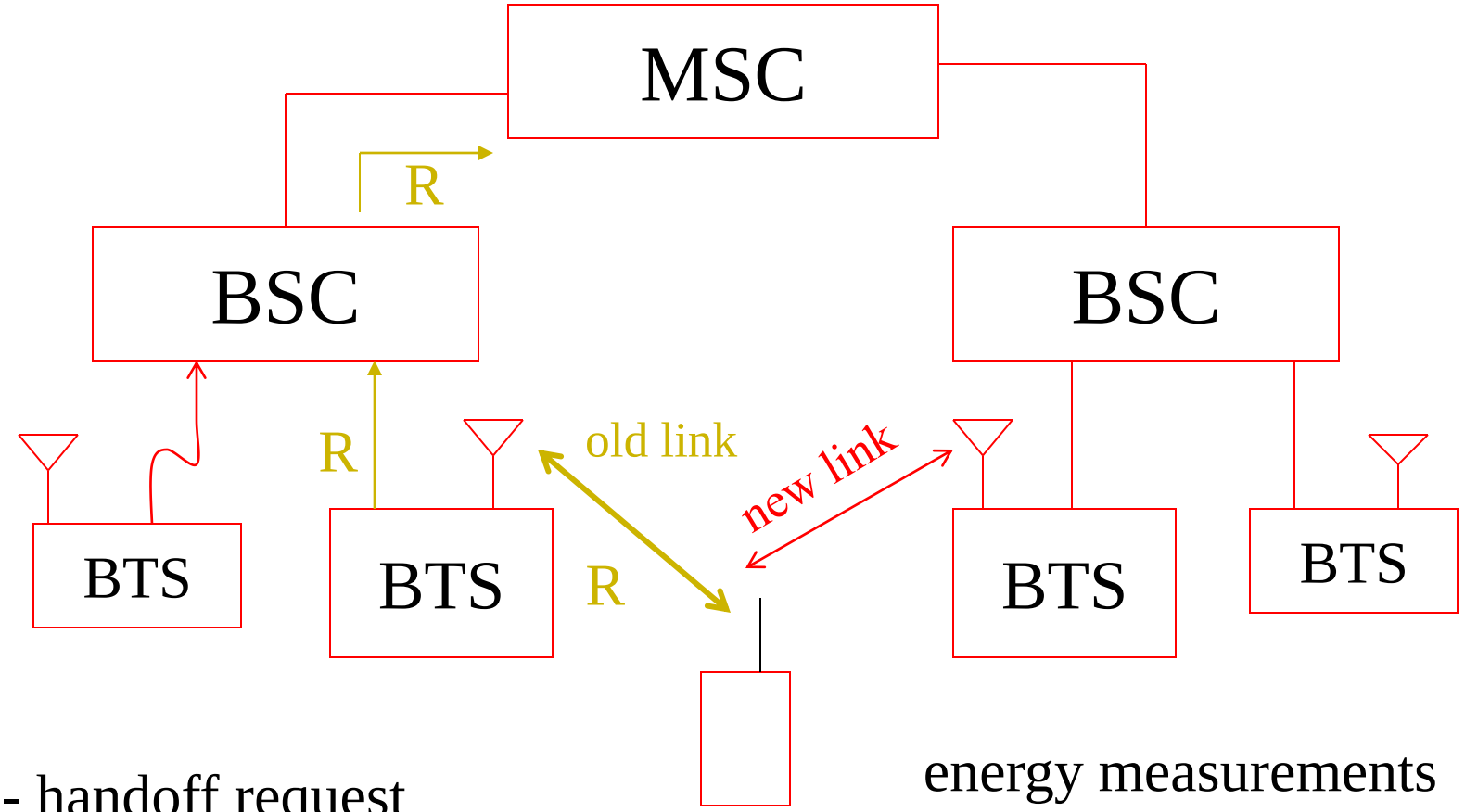
- Soft Handoff
  - Mobile commences Communication with a new BS without interrupting communication with old BS
  - same frequency assignment between old and new BS
  - provides different site selection diversity
- Softer Handoff
  - Handoff between sectors in a cell
- CDMA to CDMA hard handoff
  - Mobile transmits between two base stations with different frequency assignment

Soft Handoff- A unique feature of CDMA Mobile

Advantages

- Contact with new base station is made before the call is switched
- Diversity combining is used between multiple cell sites
  - additional resistance to fading
- If the new cell is loaded to capacity, handoff can still be performed for a small increase in BER
- Neither the mobile nor the base station is required to change frequency

Soft Handoff Architecture



R- handoff request
sent to the old cell

energy measurements
are made at the mobile