# Antennas and Coverage

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**Problem**

A telecommunication company has to install some antennas to cover a region. The region in divided into a set of zones Z. The company can install antennas in a set of candidate sites S. Given a candidate site $i \in S$ and a zone $j \in Z$ it is known the level of the received signal $p_{ij}$. A zone can be served by at most one active antenna and the signal received from that antennas must be greater or equal than $\Delta$.

Formulate the problem of maximizing the number of served zones as a linear optimization problem.

**Variant:** In order to avoid poor quality solutions, the company has to introduce constraints on the interference. If a zone j is served by one antenna i, the total of the received signals (minus that of the antenna serving the zone) must be less than or equal to $\delta$.

I modeled the problem in a way that could be solved using AMPL.

**Parameters and sets:**

```
2 set Z;      #set of zones to be covered
3 set S;      #set of sites for antennas
```

```
6 param p{S,Z}, default 0;
7 param DELTA;
8 param delta;
```

**Variable Sets,** Indicate the indexes and their range, the meaning of the variables and their nature (binary, integer...):

```
11 var x{S}, binary;   # |x| = number of active antennas
12 var y{Z}, binary;   # |y| = number of covered zones
```

$x_i = 1$ if the antenna is active on site $i$.
$x_i = 0$ if the antenna is not active on site $i$.
$y_j = 1$ if zone $j$ is covered by some antennas.
$y_j = 0$ if zone $j$ is not covered by any antenna.

**Objective function:**

```
15 #maximize number of active zones
16 maximize zones:
17     sum{z in Z} y[z];
```

**Constraints about each zone being served by at most one antenna:**

```
20 subject to antennas{z in Z}:
21     sum{s in S: p[s,z] >= DELTA} x[s] <= 1;
```

There can not be more than one active antenna that serves each zone.

**Constraints about signal quality:**

```
23 subject to signal{z in Z}:
24     y[z] <= sum{s in S: p[s,z] >= DELTA} x[s];
```

Each zone is served only if there is an antenna that transmits a signal greater or equal than $\Delta$.

**Other constraints if needed:**

No other constraint is required.

**Constraints of the variant:**

```
27 subject to interference{z in Z}:
28     ((sum{s in S} (p[s,z]*x[s])) -
29     (sum{s in S: p[s,z] >= DELTA} (p[s,z]*x[s])))
30     <= delta;
```

Literally, the sum of all the signals received by each zone minus the signal of the antenna that serves the zone must be less or equal than $\delta$.