Wireless Sensor Networks

Chiara Buratti

c.buratti@unibo.it
+39 051 20 93147

Office Hours:
Tuesday 3 – 5 pm @ Main Building, third floor

Credits: 6

To fix the Ideas..

Discussion & Exercise

IEEE 802.15.4 MAC Protocol
Coexistence Issues

Consider 144 IEEE 802.15.4 nodes working in beacon-enabled mode and deployed on a grid (12 x 12). Denote as *d=20 m* the distance between two subsequent nodes in the grid.
Assume no channel fluctuations are present, and the Loss in dB is given by:
$L[dB]=k_0+k_1 \ln(d)$, where $k_0=40$ dB, $k_1=17.37$ and ln is the natural logarithm.

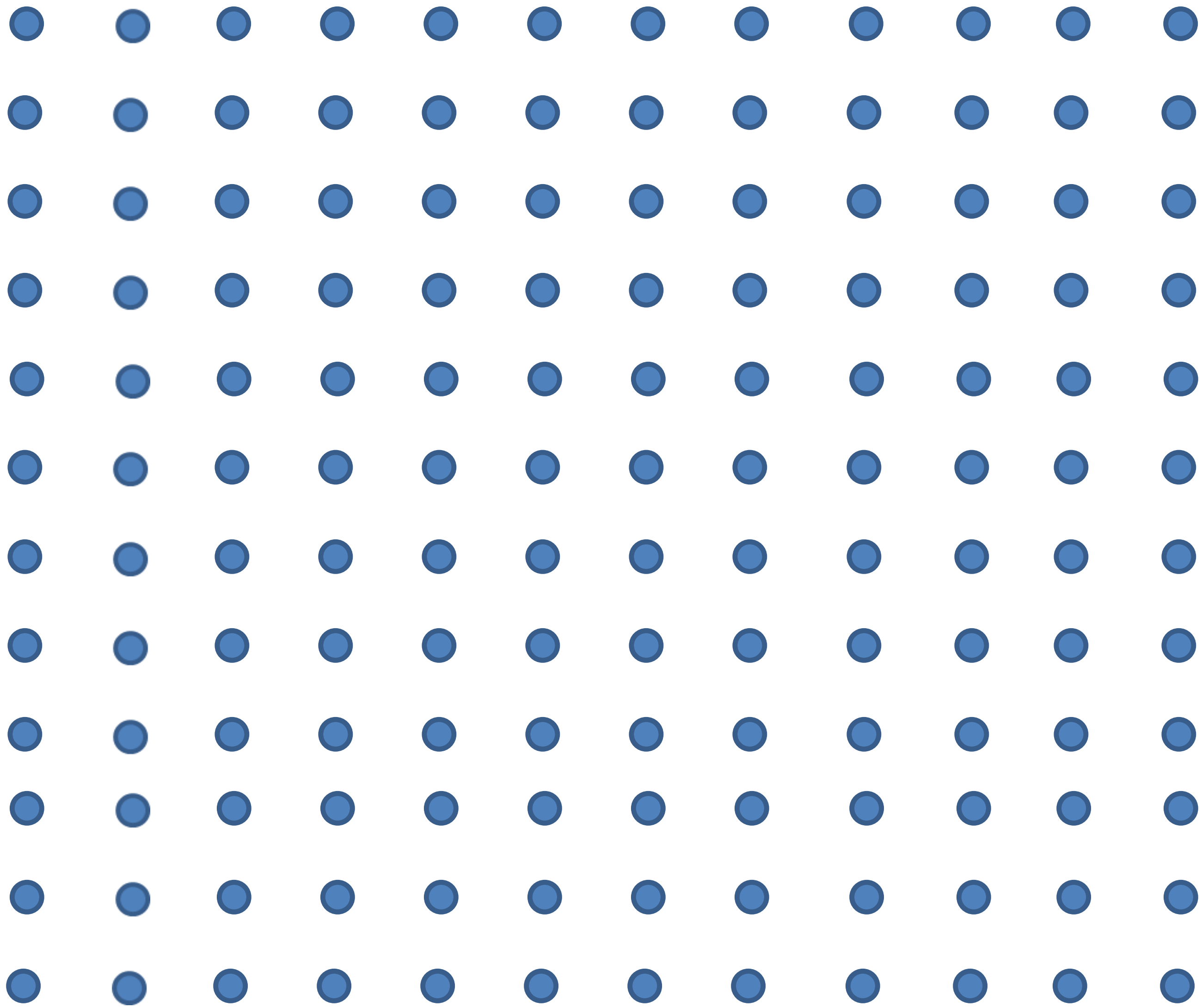
Nodes transmit at 0 dBm and we assume that: i) the transmission range and the sensing range is equal to $5\,d\sqrt{2}$

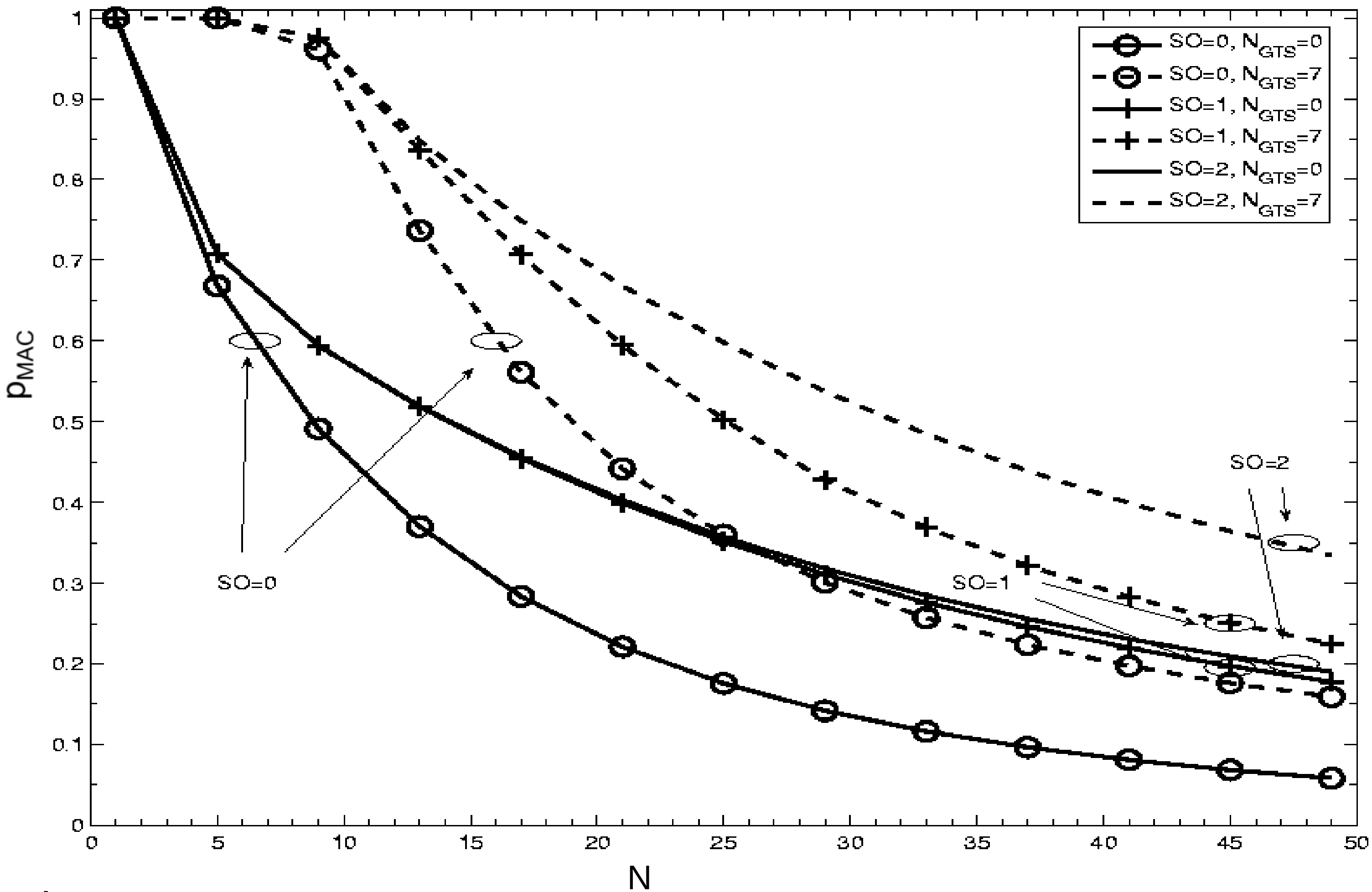
Assume in the area there are two APs Wi-Fi working on channels 6 and 11 and that no adiacent channels could be assigned to the different PANs in the area.

A query based application must be implemented: PAN Coordinators have to receive data from nodes at maximum every 32 ms.

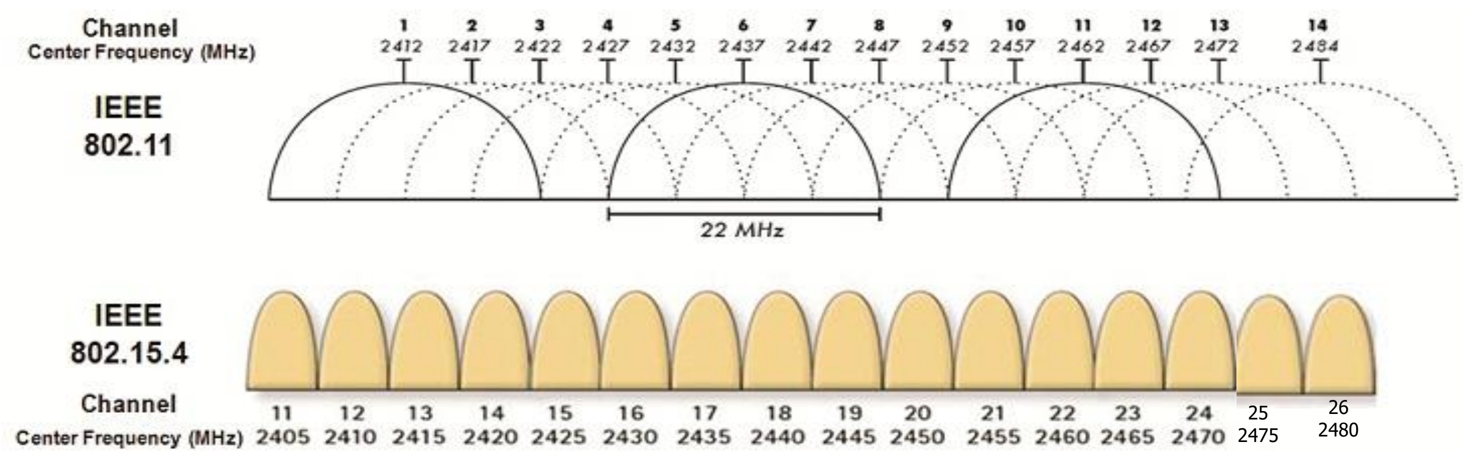
No retransmissions must be implemented to reduce energy consumption. 7 GTS can be assigned.
We assume the capture threshold is infinite (frames are lost in case of collision).
By assuming that the application can tolerate a frame loss rate up to 70 %, nodes are transmitting packets of 20 bytes with 10 Bytes of payload. Evaluate the number of coordinatiors should be deployed where and using which channels.
Evaluate the average throughput generated by the WSN.

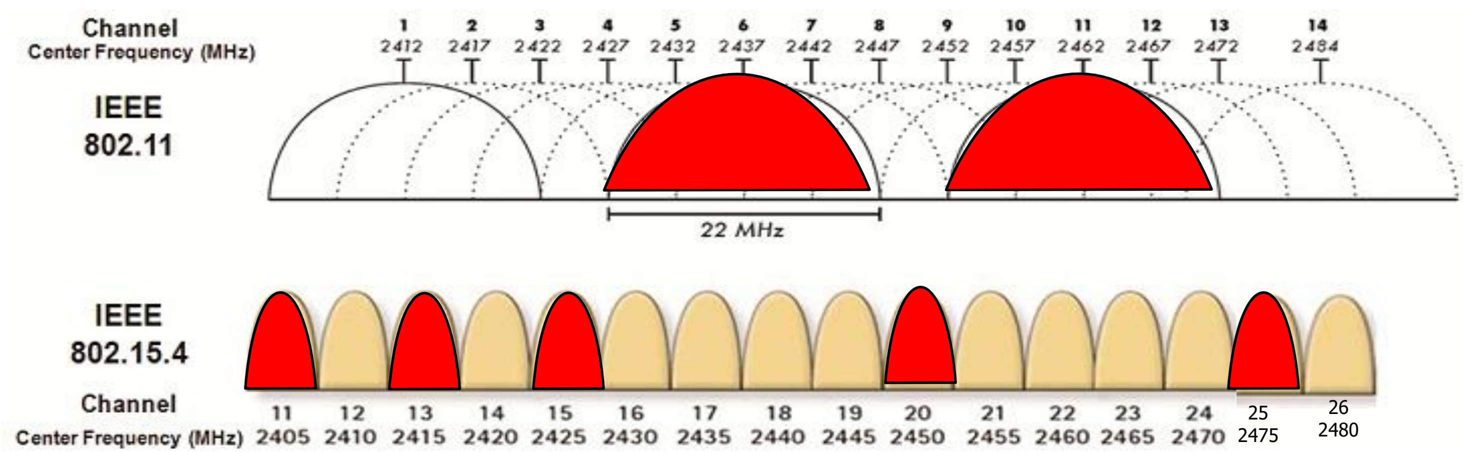
Assuming now that the application requires to have a maximum frame loss rate of 60% and no GTS may be used, reply again to the above question and check if there exists a channel assignment such that C/I > 1.3dB is guaranteed, in the absence of intra-PAN interference

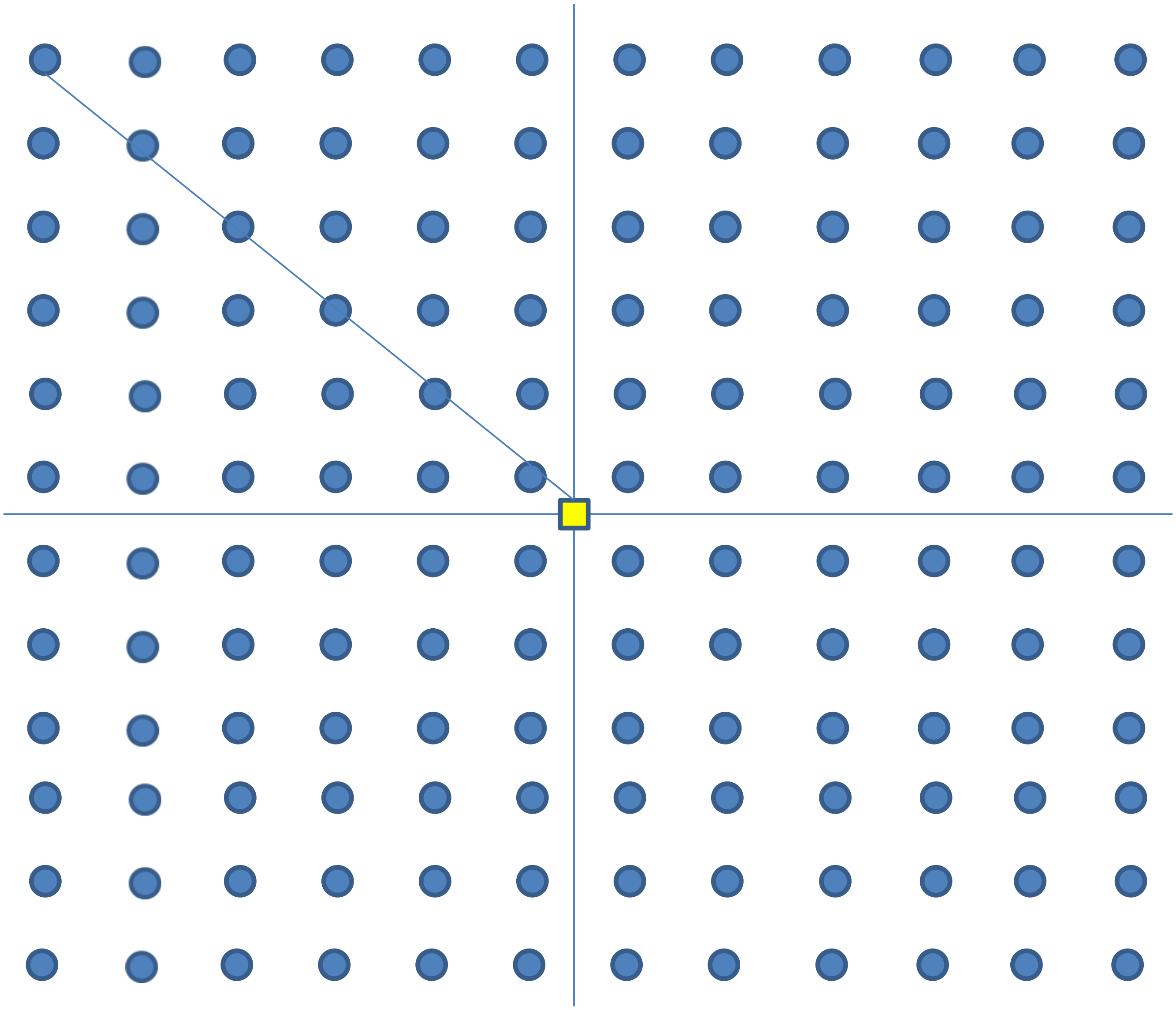




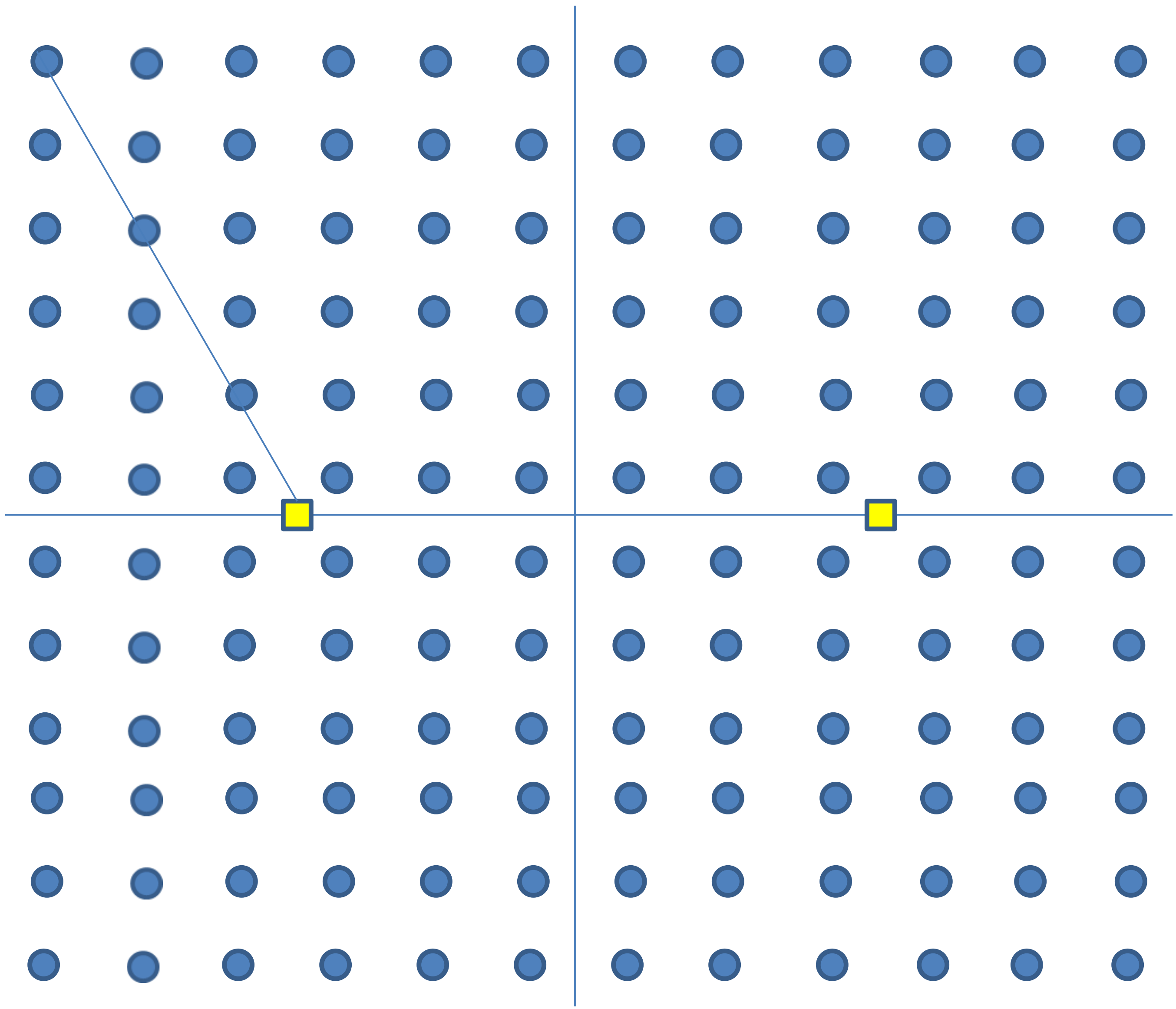
D=2
No retransmissions
No hidden terminal problem
Infinite capture threshold


Channel
Center Frequency (MHz)
1 2 3 4 5 6 7 8 9 10 11 12 13 14
2412 2417 2422 2427 2432 2437 2442 2447 2452 2457 2462 2467 2472 2484
IEEE 802.11
22 MHz
IEEE 802.15.4
Channel
Center Frequency (MHz)
11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26
2405 2410 2415 2420 2425 2430 2435 2440 2445 2450 2455 2460 2465 2470 2475 2480

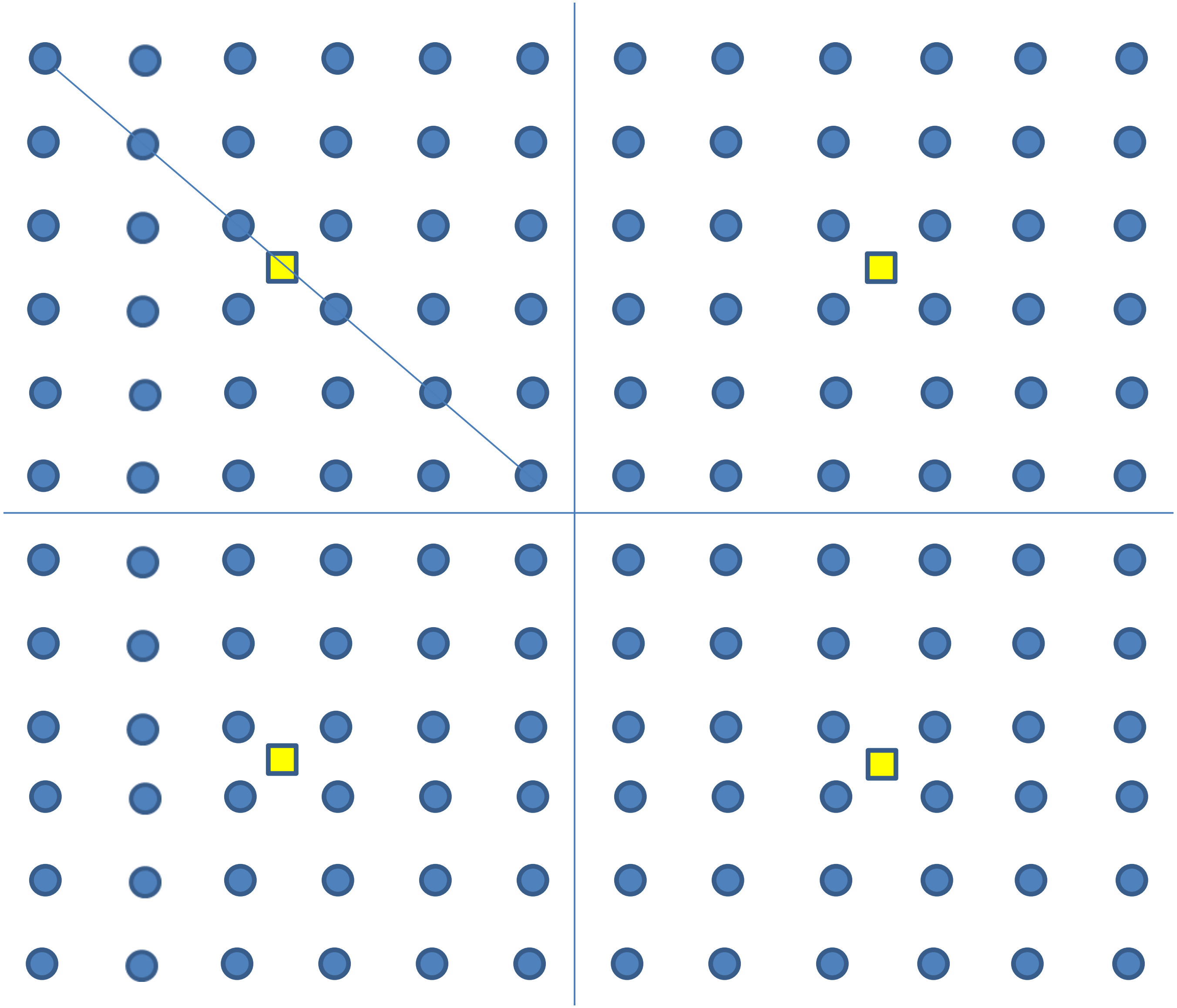

Channel
Center Frequency (MHz)
1 2 3 4 5 6 7 8 9 10 11 12 13 14
2412 2417 2422 2427 2432 2437 2442 2447 2452 2457 2462 2467 2472 2484
IEEE 802.11
22 MHz
IEEE 802.15.4
Channel
Center Frequency (MHz)
11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26
2405 2410 2415 2420 2425 2430 2435 2440 2445 2450 2455 2460 2465 2470 2475 2480



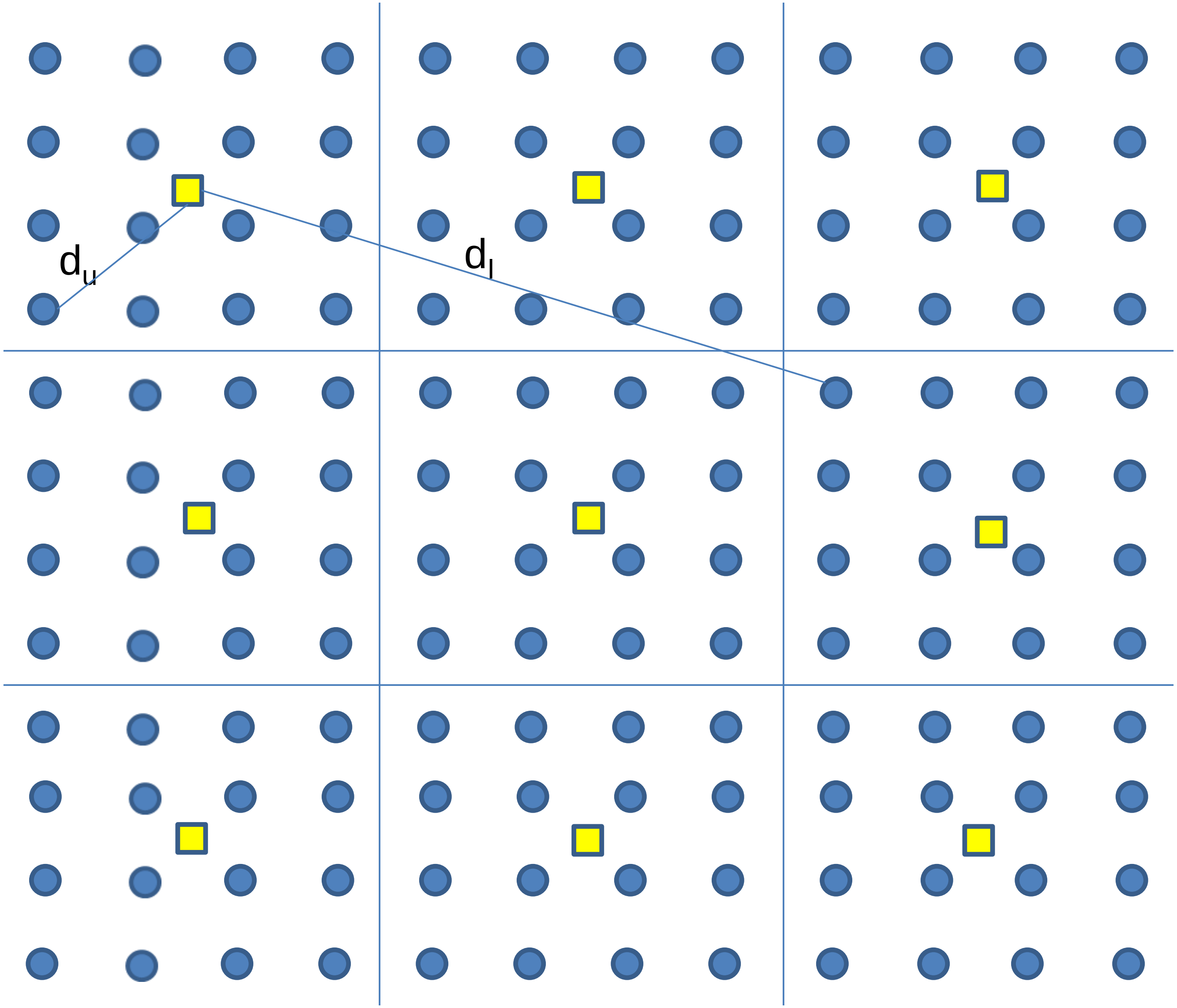
Chiara Buratti
DEI, University of Bologna

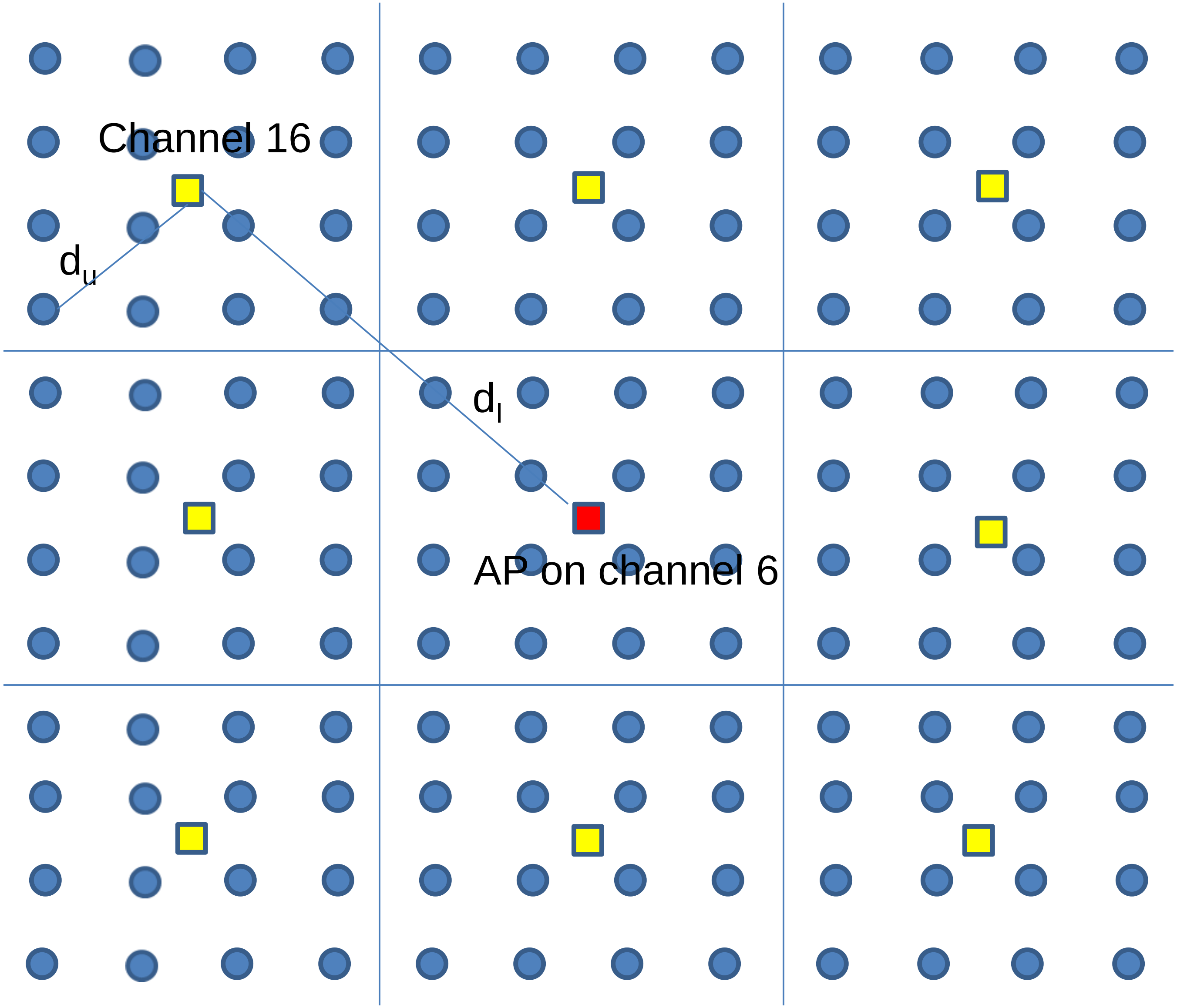


Chiara Buratti
DEI, University of Bologna



Chiara Buratti
DEI, University of Bologna




Channel 16
d_u
d_l
AP on channel 6

Chiara Buratti
DEI, University of Bologna

Frequency Domain Characterization

- $p_{int}^{(i,j)}$ → The percentage of interfering power falling into the 802.15.4 receiver band Indexes (i) and (j) refer to the channel used by the 802.15.4 and by the 802.11 networks, respectively.
- W(f) → The power spectral density of the interfering signal
- $F_r(f)$ → The receiver filter transfer function

$$p_{int}^{(i,j)} = \frac{1}{\int_{-\infty}^{+\infty} W^{(j)}(f)df} \cdot \int_{B^{(i)}} W^{(j)}(f)|F_r(f)|^2 df \qquad |F_r(f)| = \begin{cases} 1 & \text{if } f \in B^{(i)} \\ 0 & \text{otherwise} \end{cases}$$

IEEE 802.11 channel	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1	24.52	24.82	24.82	22.06	0.508	0.086	0.028	0.010	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002
2	2.98	24.52	24.82	24.82	22.06	0.508	0.086	0.028	0.010	0.002	0.002	0.002	0.002	0.002	0.002	0.002
3	0.109	2.98	24.52	24.82	24.82	22.06	0.508	0.086	0.028	0.010	0.002	0.002	0.002	0.002	0.002	0.002
4	0.032	0.109	2.98	24.52	24.82	24.82	22.06	0.508	0.086	0.028	0.010	0.002	0.002	0.002	0.002	0.002
5	0.014	0.032	0.109	2.98	24.52	24.82	24.82	22.06	0.508	0.086	0.028	0.010	0.002	0.002	0.002	0.002
6	0.003	0.014	0.032	0.109	2.98	24.52	24.82	24.82	22.06	0.508	0.086	0.028	0.010	0.002	0.002	0.002
7	0.002	0.003	0.014	0.032	0.109	2.98	24.52	24.82	24.82	22.06	0.508	0.086	0.028	0.010	0.002	0.002
8	0.002	0.002	0.003	0.014	0.032	0.109	2.98	24.52	24.82	24.82	22.06	0.508	0.086	0.028	0.010	0.002
9	0.002	0.002	0.002	0.003	0.014	0.032	0.109	2.98	24.52	24.82	24.82	22.06	0.508	0.086	0.028	0.010
10	0.002	0.002	0.002	0.002	0.003	0.014	0.032	0.109	2.98	24.52	24.82	24.82	22.06	0.508	0.086	0.028
11	0.002	0.002	0.002	0.002	0.002	0.003	0.014	0.032	0.109	2.98	24.52	24.82	24.82	22.06	0.508	0.086
12	0.002	0.002	0.002	0.002	0.002	0.002	0.003	0.014	0.032	0.109	2.98	24.52	24.82	24.82	22.06	0.508
13	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.003	0.014	0.032	0.109	2.98	24.52	24.82	24.82	22.06

Wireless Sensor Networks

Chiara Buratti

www.chiaraburatti.org

c.buratti@unibo.it