Identification Systems
Lecture 4

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Examples of constrained devices

- Smartcards / Javacards
- RFID tags
- Pervasive systems / sensors

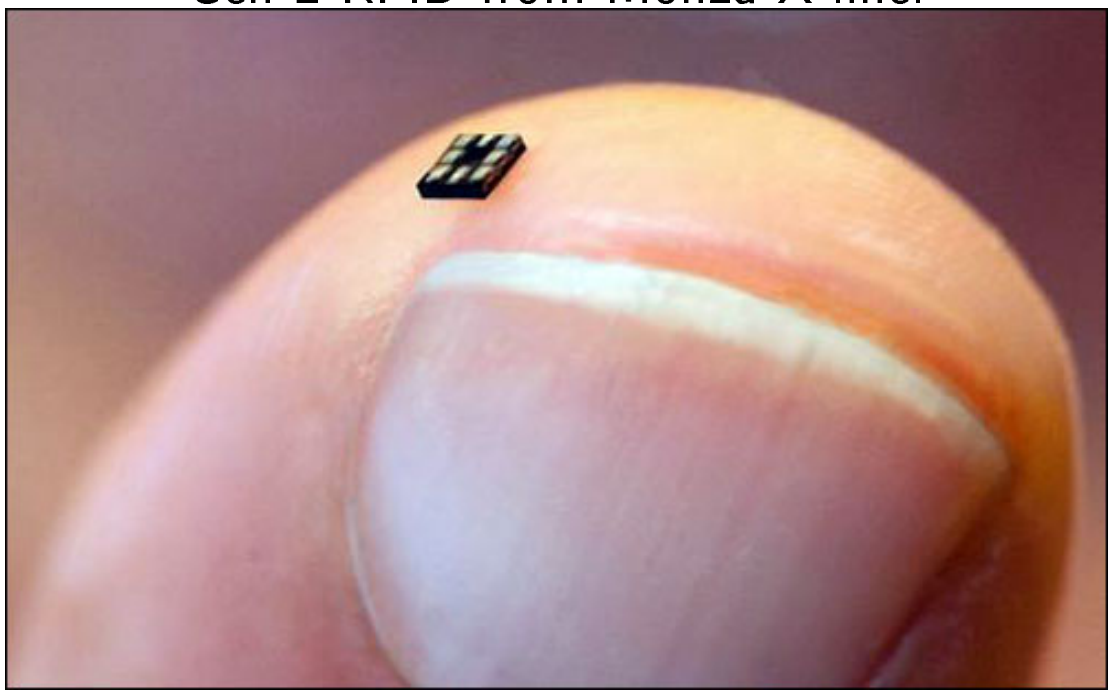
RFID systems

- varying computation power
- active tags vs passive tags
- applications from QR successor, pet door opener to documents



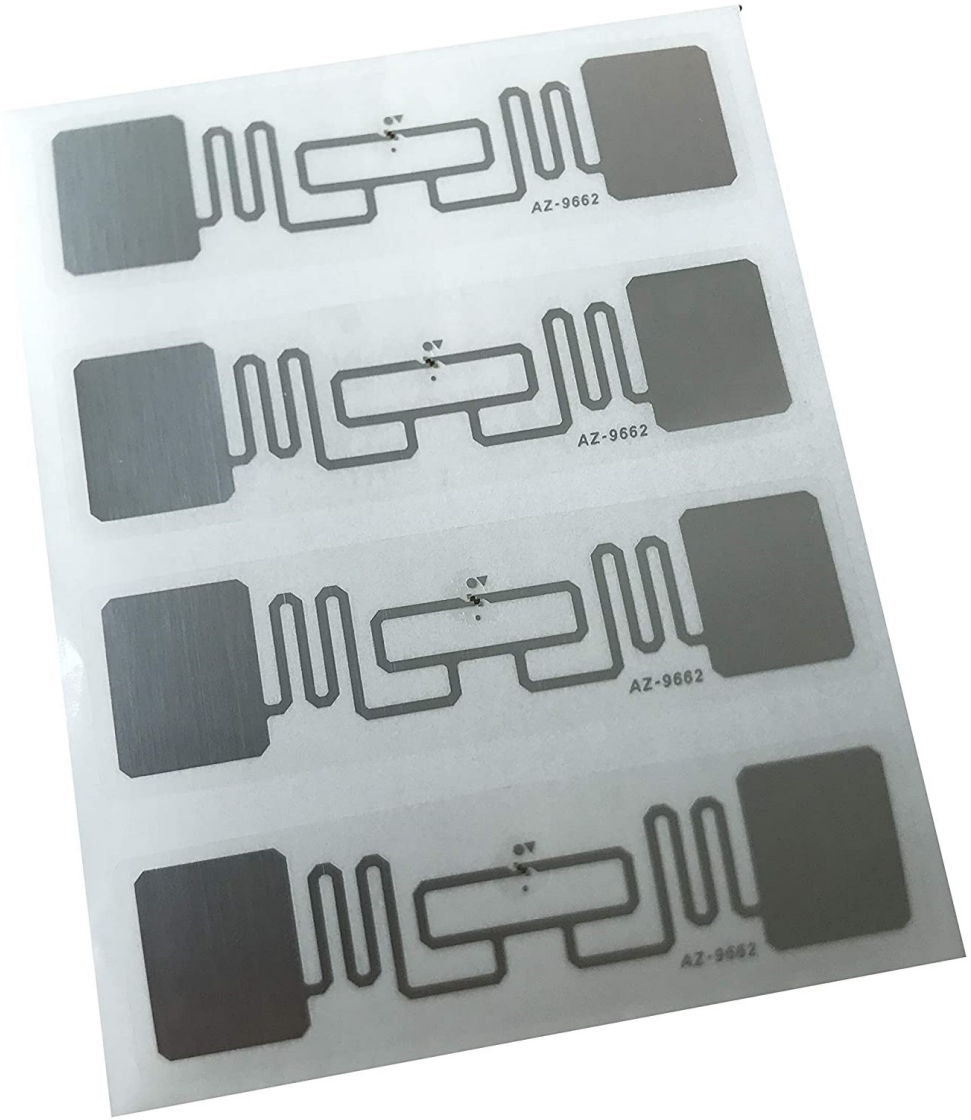
RFID systems

Gen-2 RFID from Monza-X line.

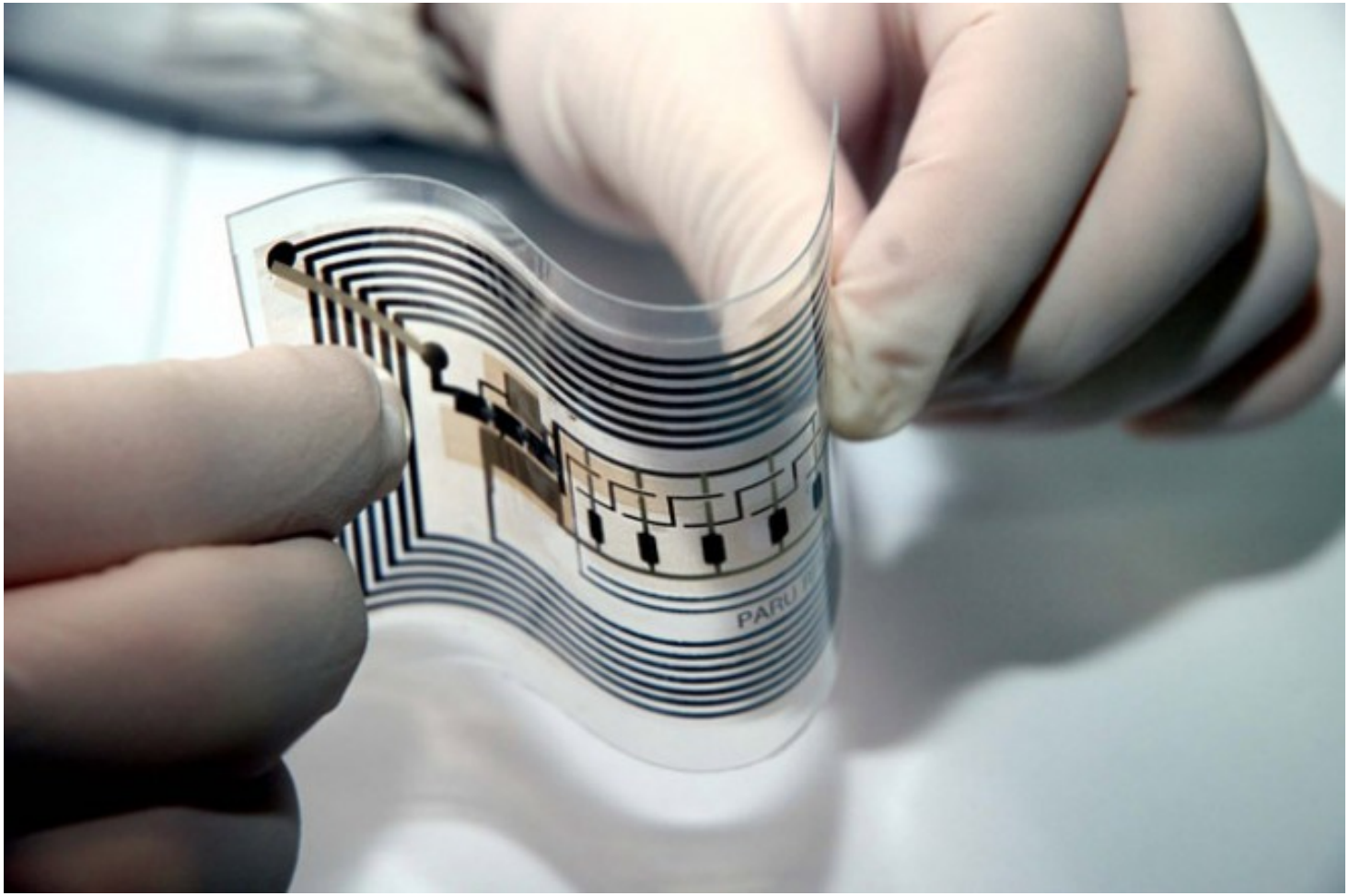


MX-8K provides 128b EPC and 8Kb User memory with physical size of 2x2x0.35 mm.

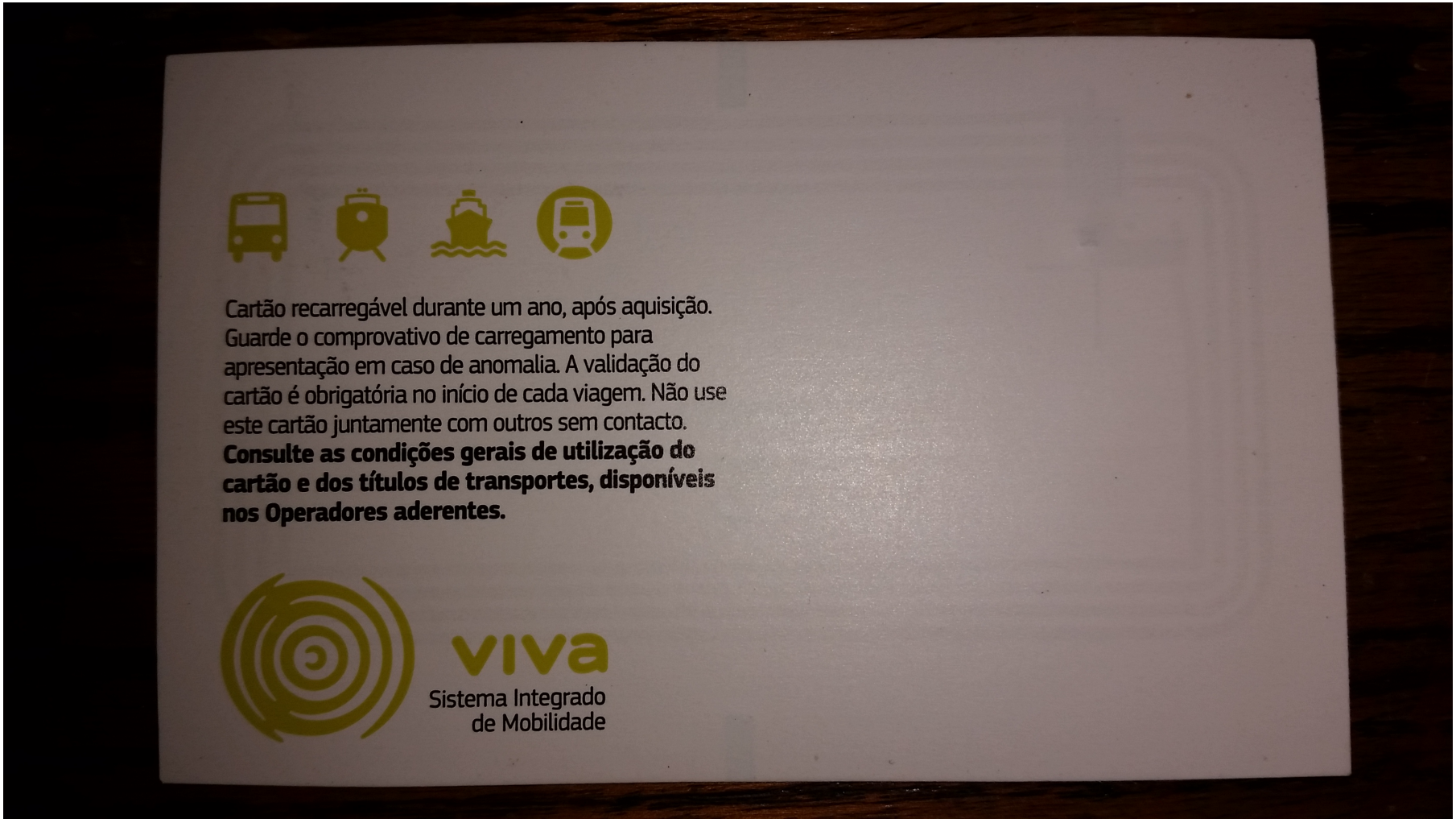
RFID systems



RFID systems



RFID systems

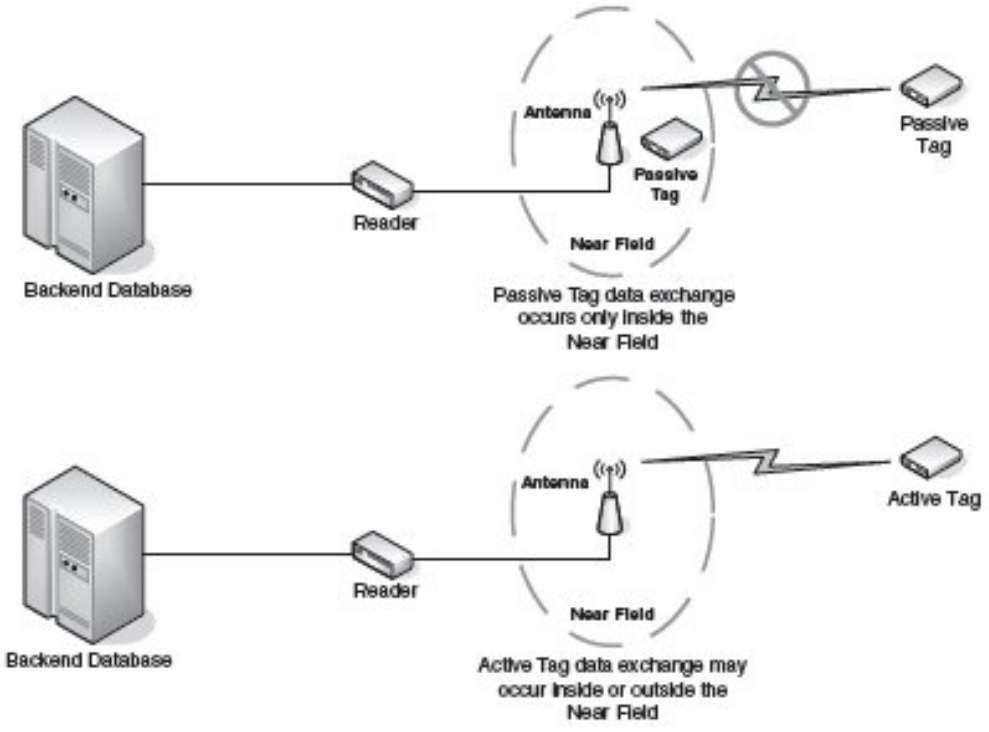


Tag Classes

EPC and ISO18000 describe:

- Class 0 : Read Only, passive tags
- Class 1 : Read Only, passive tags with unique ID (more memory and greater range)
- Class 2 : Read and Write (65K), passive tags
- Class 3 : Read and Write (65K), semi-passive tags with battery for increased range
- Class 4 : Read and Write, active tags able to communicate between each other
- Class 5 : Read and Write, active tags able to communicate with C4, C5 and stronger devices (protected memory)

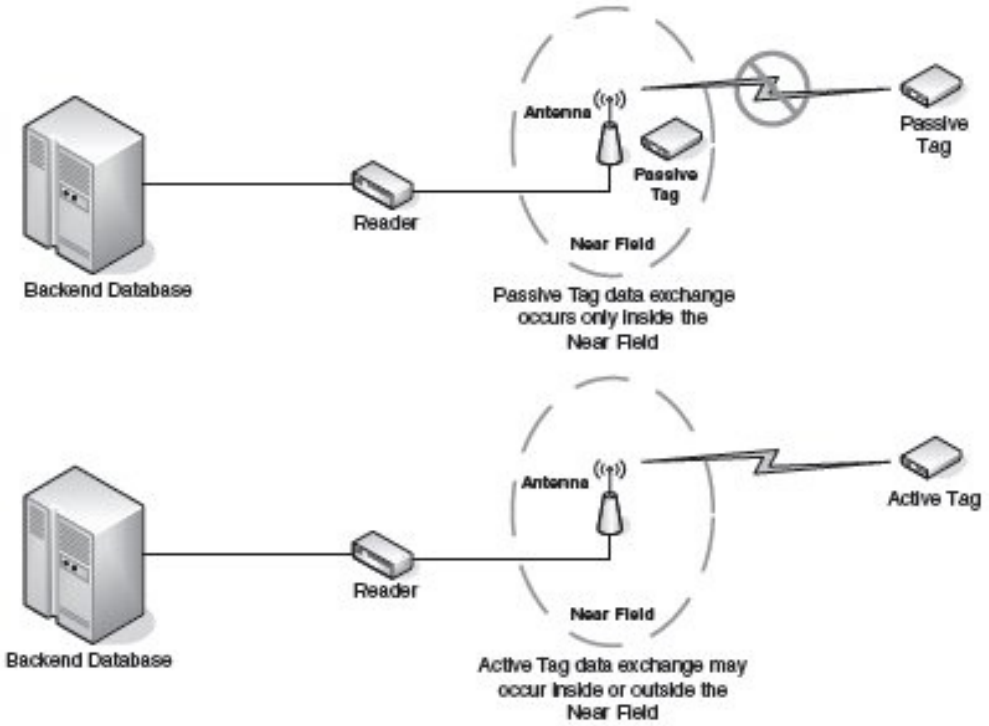
Communication



Communication models:

- MAC
- Beeping-model

Communication



Communication models:

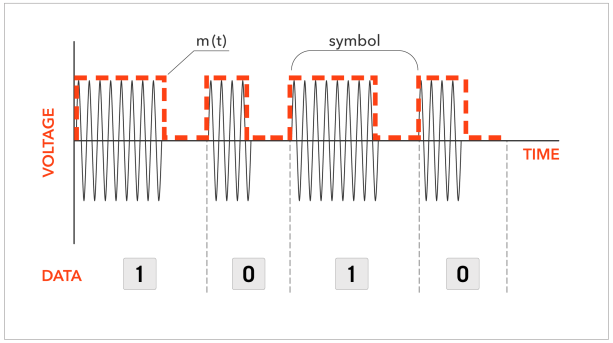
- MAC
- Beeping-model

Problem: Collisions – multiple tags in reader's range.

Coding

Images from www.atlasrfidstore.com





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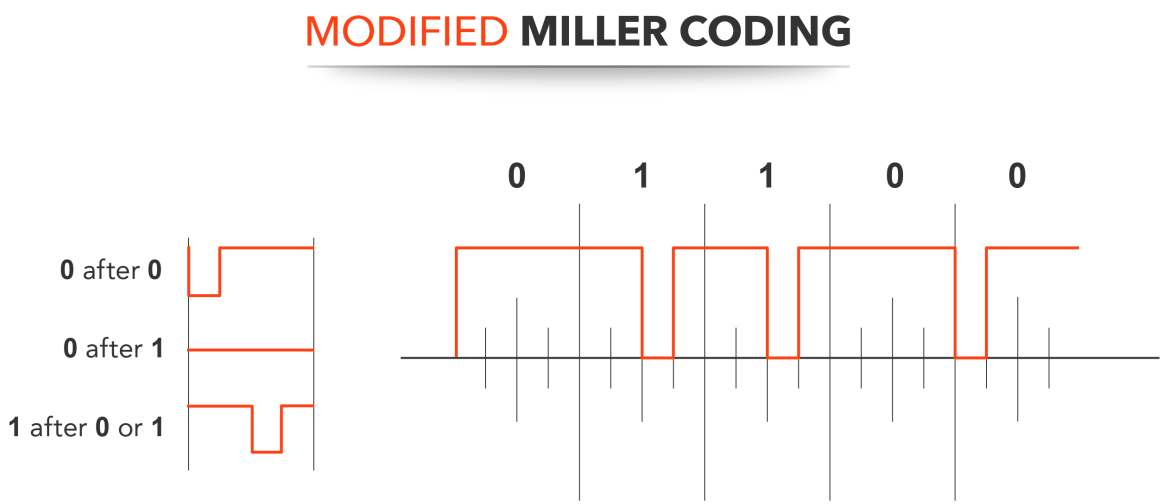

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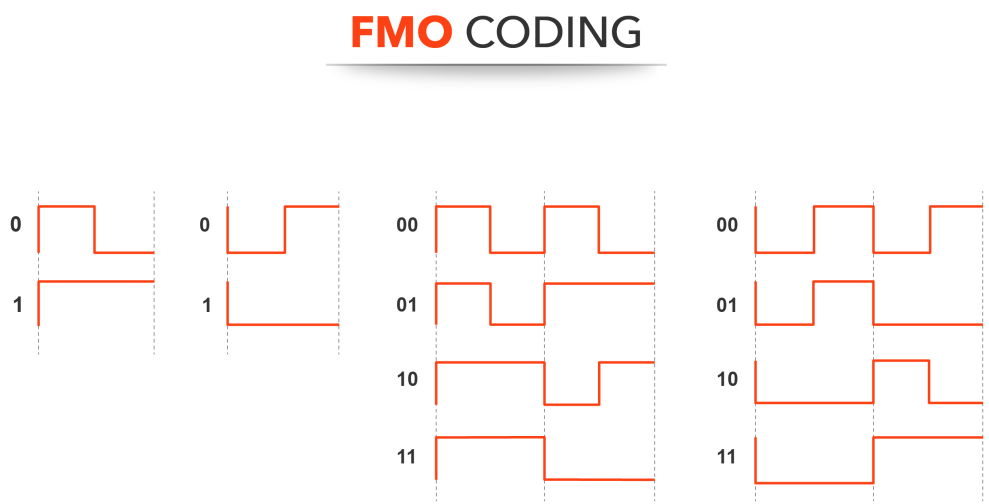
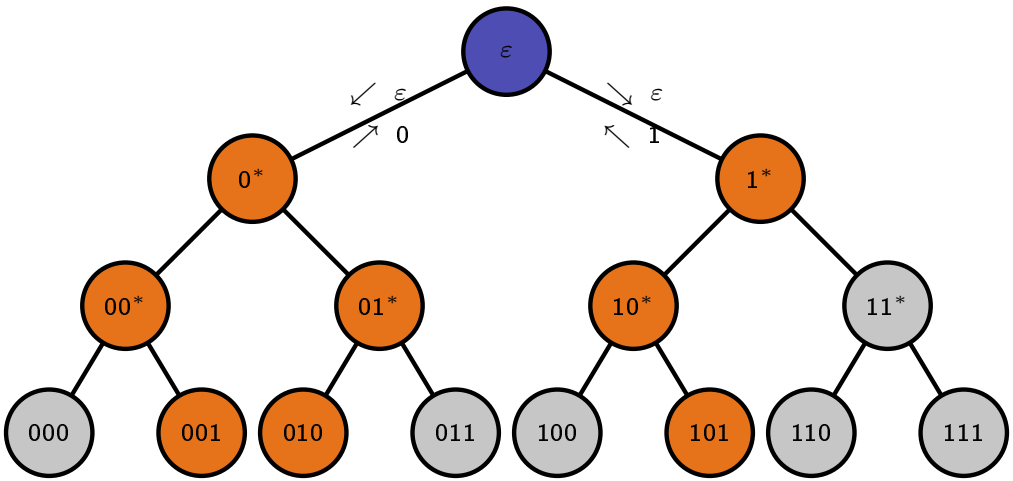


Query Tree



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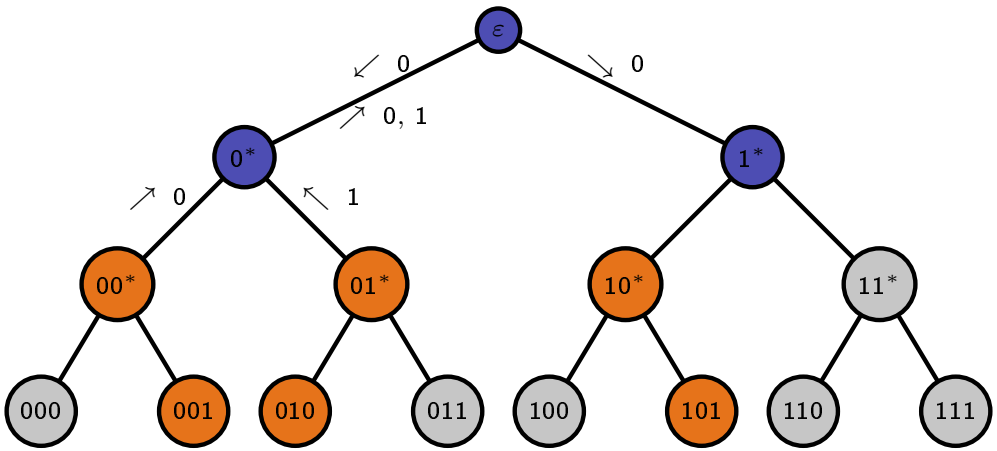

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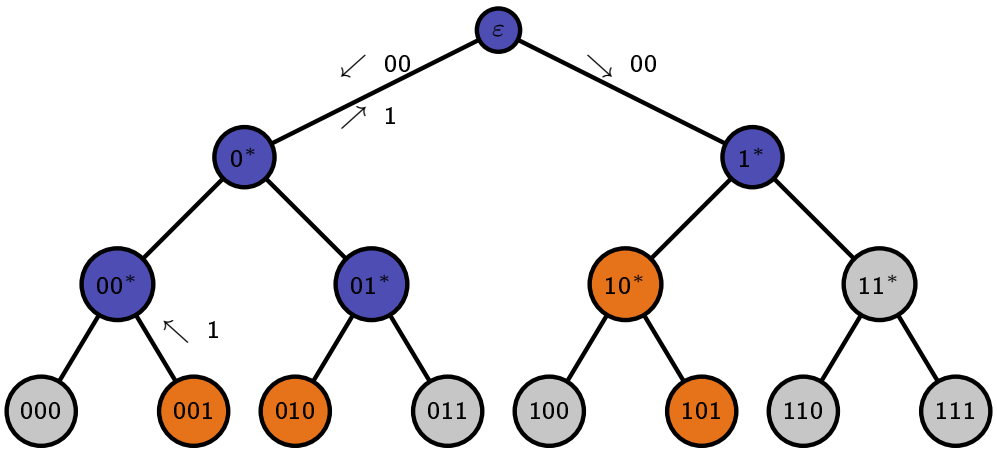

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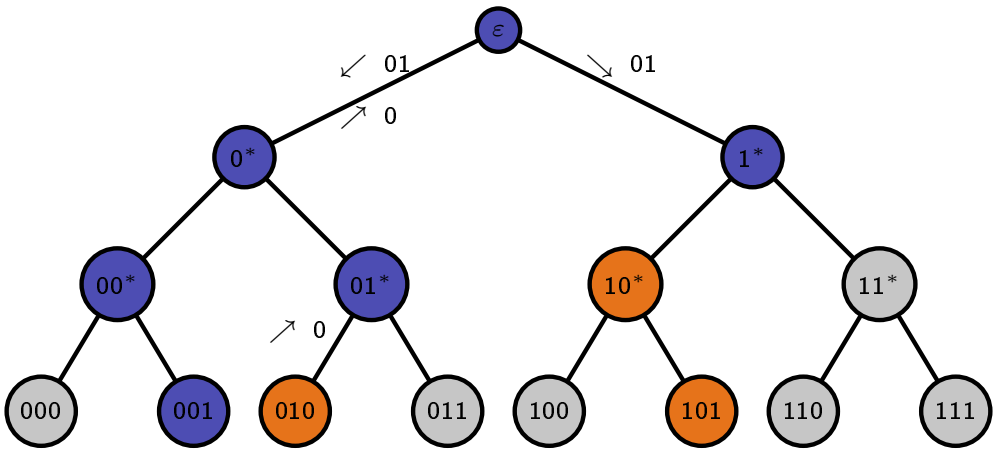

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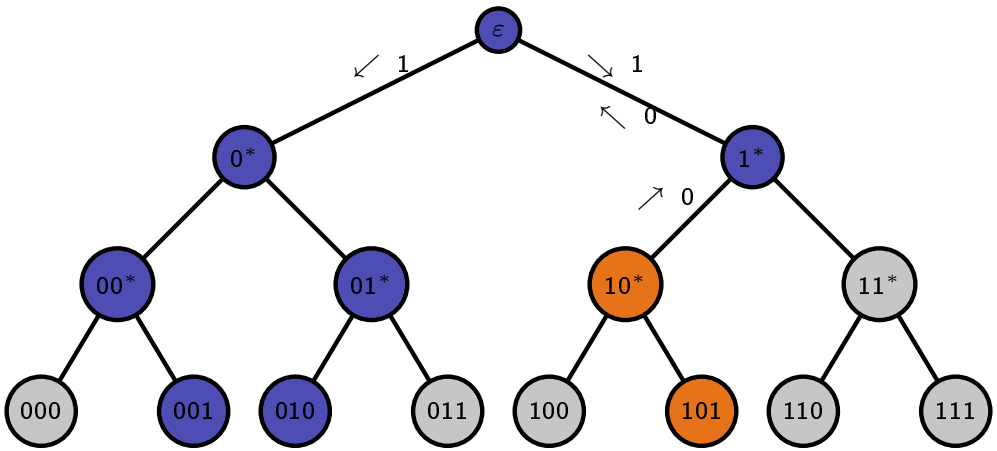

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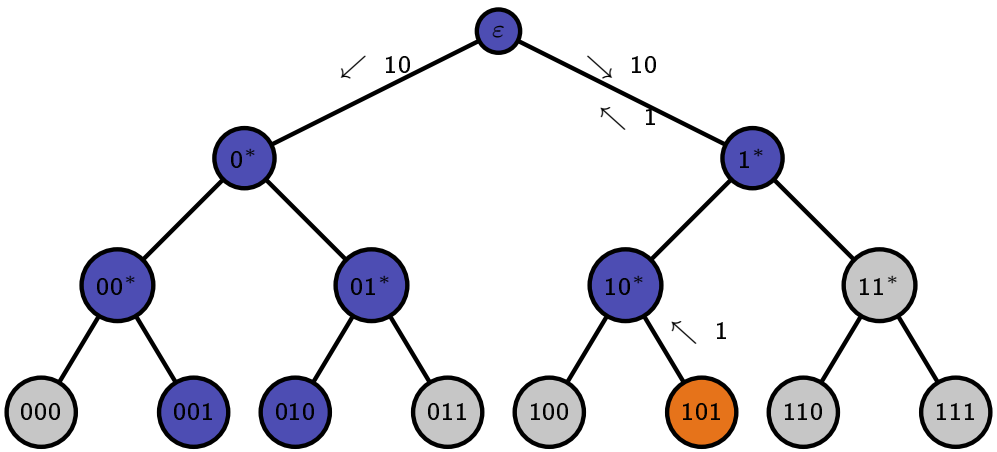

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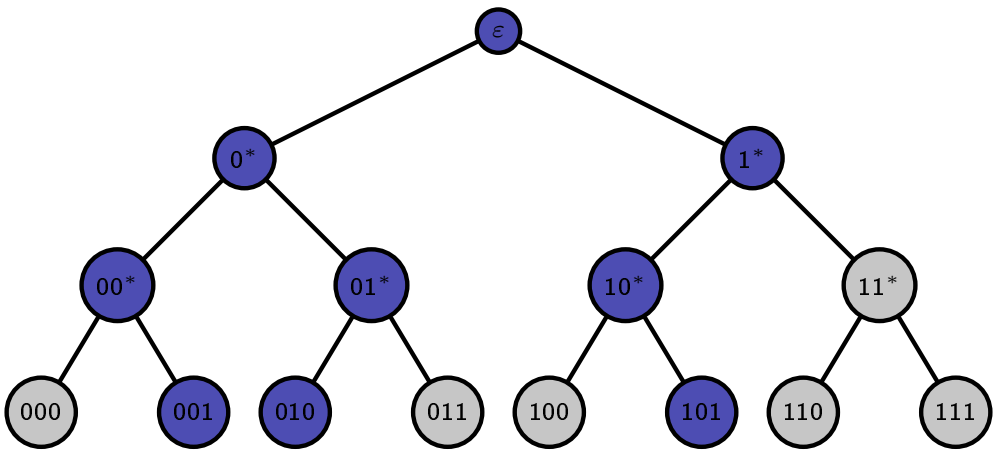

ALOHA – idea

- (Pure) ALOHA vs Slotted Aloha
- Send information whenever it is ready (for simplification enumerate it and add sender's ID)
- If no ACK-msg with the identifier is received – wait a random time and resend the message

Advantages:

- Simple method of transmission between reader and multiple tags
- Tags do not require synchronization
- Messages may be of arbitrary lengths
- Messages are sent immediately

E.g., protocol based on ALOHA by Chen and Kao.

Threats

- Denial of Service
- Tag cloning
- Privacy threats (eavesdropping, tracking, product identification, . . .)

Eavesdropping protection

Wang et al., *Securing Deployed RFIDs by Randomizing the Modulation and the Channel*

Communication : HF (13.56MHz, up to 10cm range), UHF (915MHz, up to 7m range).

Tags : Passive, wave modulation for data transmission.

Receiver : Perceives signal $y(t) = h_{rr}c(t) + h_{tr}x(t)c(t)$.

LocRF : Introduces random modulation to confuse the eavesdropper.

Eavesdropping protection

Wang et al., *Securing Deployed RFIDs by Randomizing the Modulation and the Channel*

Idea : Substituting the carrier $c(t)$ by a random noise $r(t)$ so that $y_{\text{reader}}(t)$ is readable and $y_{\text{eavesdropper}}(t)$ is hard to decode.

Frequency : Reader-generated $r(t)$ has to uphold to tag's response time (we assume 2MHz bandwidth), hence $2 \cdot 10^6$ complex samples per second is generated at random and quantized to 32b (due to DtA converter).

Eavesdropper's POV : After normalization, the eavesdropper perceives $y'(t) = r(t)[1 + \frac{h_{ce}}{h_{re}} x(t)]$.

Reader's POV : $y(t) = r(t)[h_{\text{self}} + h_{cr} x(t)]$. Since $r(t)$ is known and h_{self} may be removed due to circulator in full-duplex systems, the signal to be decoded stays as $\hat{y}(t) = h_{cr} x(t) r(t)$.

Eavesdropping protection

Wang et al., *Securing Deployed RFIDs by Randomizing the Modulation and the Channel*

Security:
For each bit b sent by the tag, adversary perceives k samples $(Y_1, \ldots, Y_k)$ $Y_i = R_i(1 + p_i^b)$, where R_i is randomly selected from complex Gausian distribution, and $(p_1^b, \ldots, p_k^b)$. Naturally, $p \approx \frac{h_{ce}}{h_{re}} x_0$ or $p \approx \frac{h_{ce}}{h_{re}} x_1$.
The maximum likelihood decoder compares probabilities $\Pr[b = 0|(Y_1, \ldots, Y_k)]$ and $\Pr[b = 1|(Y_1, \ldots, Y_k)]$. Since x_1 and x_0 are independent and equally probable, we can consider $\Pr[(Y_1, \ldots, Y_k)|b = 0]$ and $\Pr[(Y_1, \ldots, Y_k)|b = 1]$. Since each of k samples is independent, $\Pr[Y|b = 0] = \frac{1}{(2\pi)^{k/2}\Pi\sigma_i^0} \exp\{-\Sigma_i^k(\frac{|Y_i|}{\sigma_i^0})^2\}$, similarly $\Pr[Y|b = 1]$.

Eavesdropping protection

Wang et al., *Securing Deployed RFIDs by Randomizing the Modulation and the Channel*

Security cont.:
Assuming the number of p^0s and p^1s to be approximately even, we can state that $\Pi\sigma_i^0 = \Pi\sigma_i^1$, hence the compared probabilities may be simplified to comparing $\Sigma_i^k(\frac{|Y_i|}{\sigma_i^0})^2$ and $\Sigma_i^k(\frac{|Y_i|}{\sigma_i^1})^2$. Utilizing specific transmission model (HF or UHF) we may simplify it even further, to verification of two 'signal windows' and check whether (for HF) $|Y_2|^2 + |Y_4|^2 + |Y_6|^2 + |Y_8|^2 > |Y_9|^2 + |Y_{11}|^2 + |Y_{13}|^2 + |Y_{15}|^2$.

Eavesdropping protection

Wang et al., *Securing Deployed RFIDs by Randomizing the Modulation and the Channel*

BER (for HF):
Let us define $U = |Y_2|^2 + |Y_4|^2 + |Y_6|^2 + |Y_8|^2$ and $V = |Y_9|^2 + |Y_{11}|^2 + |Y_{13}|^2 + |Y_{15}|^2$, additionally $Z = U - V$. For the optimal decoder, $\mathrm{BER} = \frac{1}{2}\Pr[Z < 0|b = 0] + \frac{1}{2}\Pr[Z > 0|b = 1]$. Since Ys are independent and normal distributed, $U \sim \Gamma(4, 2\sigma_U^2)$ and $V \sim \Gamma(4, 2\sigma_V^2)$, we may show that $\Pr[Z < 0|b = 0] = \Pr[Z > 0|b = 1]$ and $\Pr[Z < 0|b = 0] = \int_{-\infty}^{0} \Pr[Z = z|b = 0]dz =$
$\frac{20\mu^3}{(1+\mu)^7} + \frac{10\mu^2}{(1+\mu)^6} + \frac{4\mu}{(1+\mu)^5} + \frac{1}{(1+\mu)^4} = \mathrm{BER}$

Tracking prevention

M. Klonowski, M. Kutyłowski, PS: *Chameleon RFID and Tracking Prevention*

- Constrained RFID tags without secrets
- Adversary may capture and temper with the tags
- Honest tags security is not compromised by capturing others
- Adversary is not ubiquitous
- Even compromised tags, when not observed *for a while* become untrackable again
- **Idea:** evolution of the ID.