IEEE 802.15.4 Study

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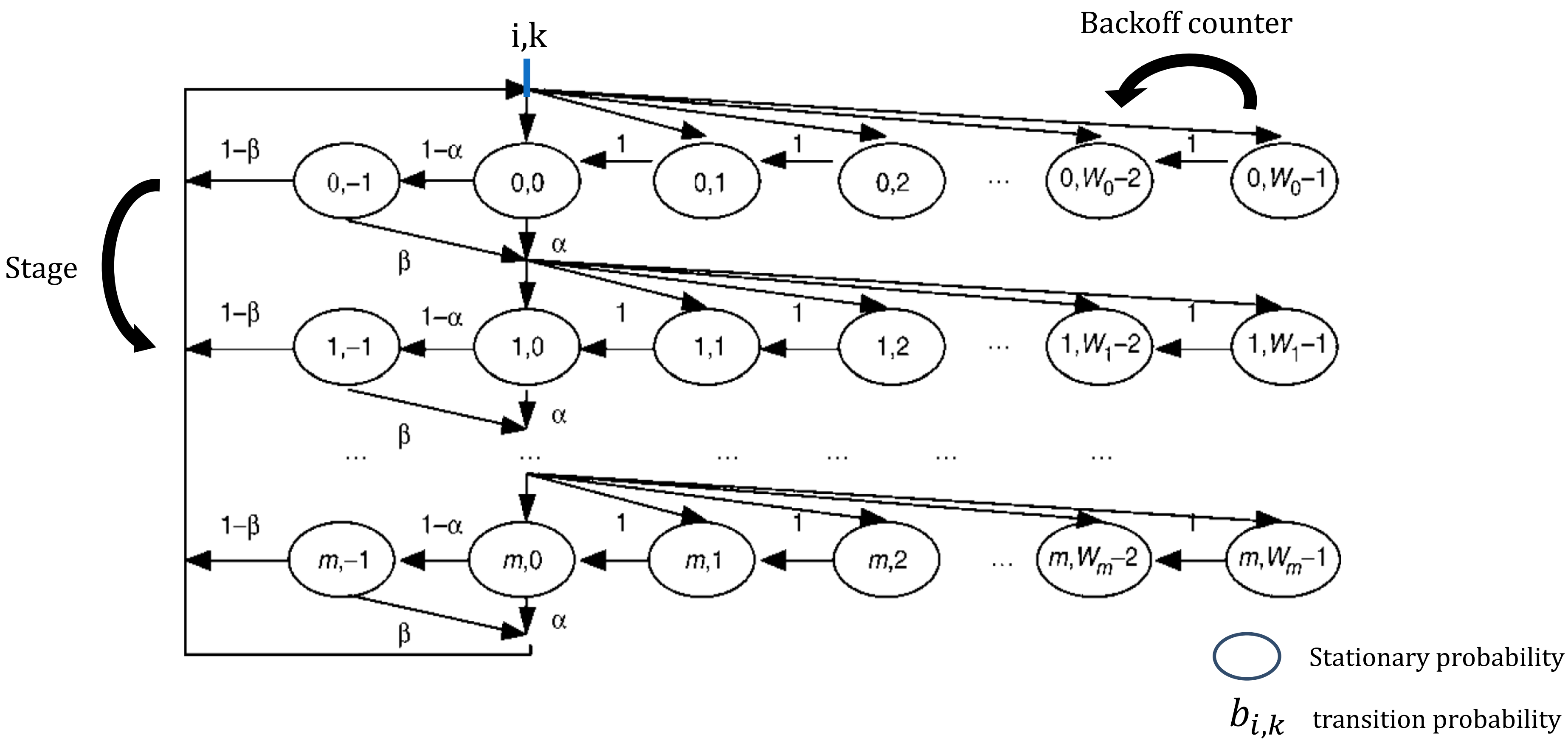
Markov chain model of IEEE 802.15.4

- *Sofie Pollin, et al. "Performance Analysis of Slotted Carrier Sense IEEE 802.15.4 Medium Access Layer"(2008)*
  - **Markov Model for IEEE 802.15.4.**

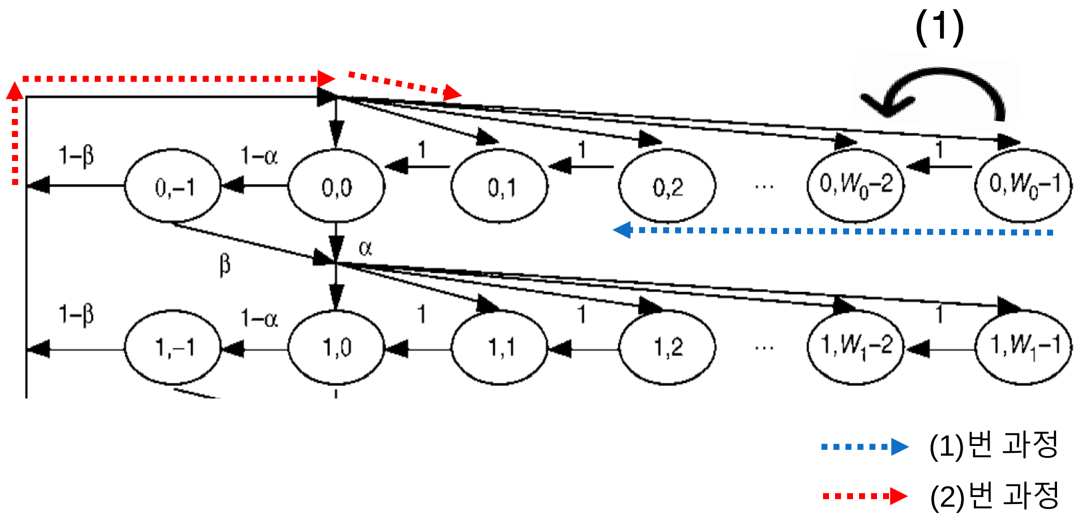


Markov chain model of IEEE 802.15.4

- transition probabilities:

$$
\begin{aligned}
P\{i,k|i,k+1\} &= 1,\ k \ge 0 && (1)\\
P\{0,k|i,0\} &= (1-\alpha)(1-\beta)/W_0,\ i < m && (2)\\
P\{i,k|i-1,0\} &= (\alpha+(1-\alpha)\beta)/W_i, && \\
& \qquad i \le m,\ k \le W_i - 1 && (3)\\
P\{0,k|m,0\} &= (1-\alpha)(1-\beta)/W_0 && (4)
\end{aligned}
$$

* $P\{a,b|a,b+1\} \rightarrow \{a,b+1\}$ 이 $\{a,b\}$ 가 될 확률



(1) Backoff counter 과정 : $b_{i,k}$ → Backoff counter

→ Stage 횟수

(2) $(1-\alpha)(1-\beta)\times\frac{1}{W_O}$ → "Backoff counter의 횟수(W_O)중에 하나의 Stationary probability"를 의미

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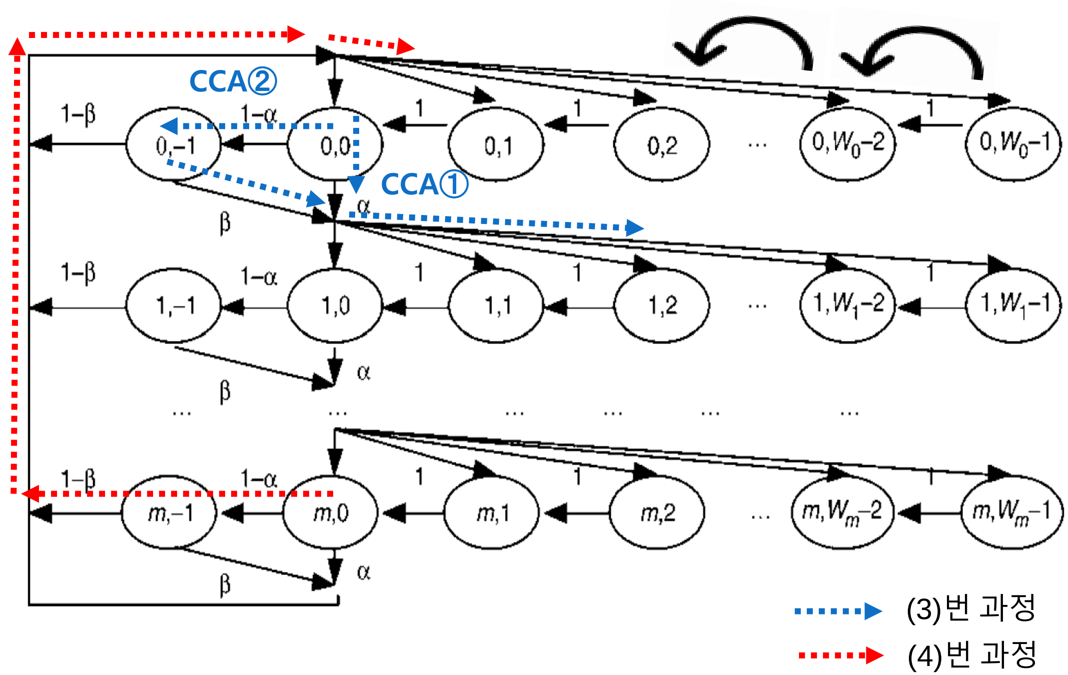

(3) $(\alpha + (1-\alpha)\beta) \times \frac{1}{W_i}$ → α : 1번째 CCA에서 실패할 확률

$(1-\alpha)\beta$: 2번째 CCA에서 실패할 확률

(4) $P\{0,k|m,0\} = (1-\alpha)(1-\beta) \times \frac{1}{W_0}$ → $\{m,0\}$에서 전송 성공후 다시 backoff counter를 통해 $\frac{1}{W_0}$가 선택될 확률

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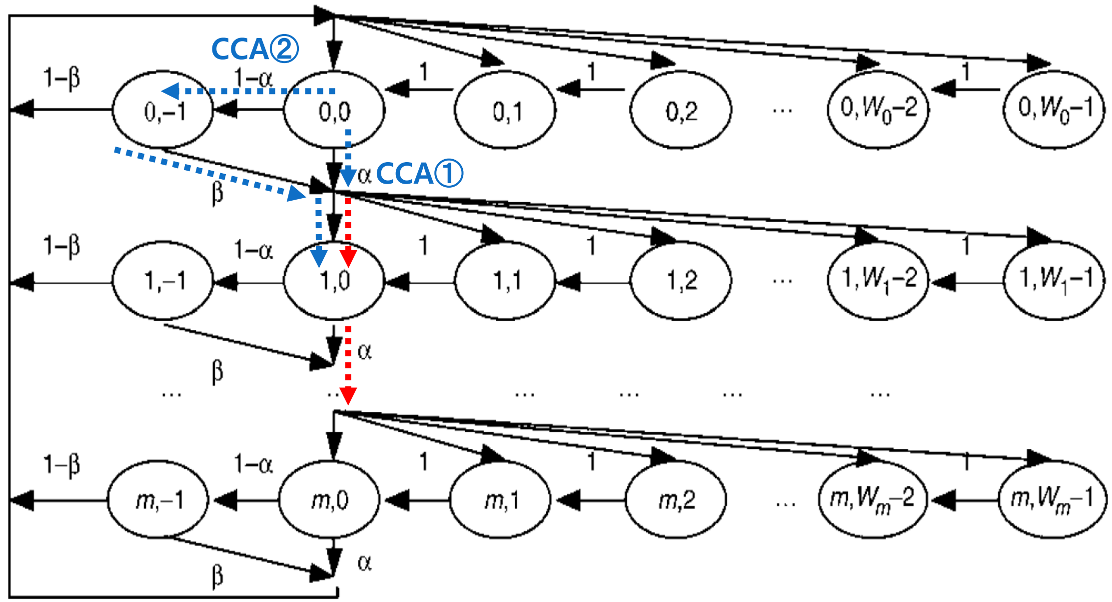
- transition probabilities:



$$(5)\ b_{i,0} = b_{i-1,0}\underbrace{\boxed{(\alpha + (1-\alpha)\beta)}}_{\text{CCA 실패 2번}} \quad 0 < i \leq m$$

$b_{i-1,0}$에서 CCA 2번 실패후 다음 stage의 i,0으로 가는 것을 의미

$$(6)\ b_{i,0} = b_{0,0}\,[(\alpha + (1-\alpha)\beta)]^{i} \quad 0 < i \leq m$$

(5) 식에

1 대입→ $b_{1,0} = b_{0,0}(\alpha + (1-\alpha)\beta)$

2 대입 → $b_{2,0} = b_{1,0}(\alpha + (1-\alpha)\beta)$

$= b_{0,0}(\alpha + (1-\alpha)\beta)\ (\alpha + (1-\alpha)\beta)$

$= b_{0,0}(\alpha + (1-\alpha)\beta)^2$

=> $\boldsymbol{b_{i,0} = b_{0,0}[(\alpha + (1-\alpha)\beta)]^{i}}$

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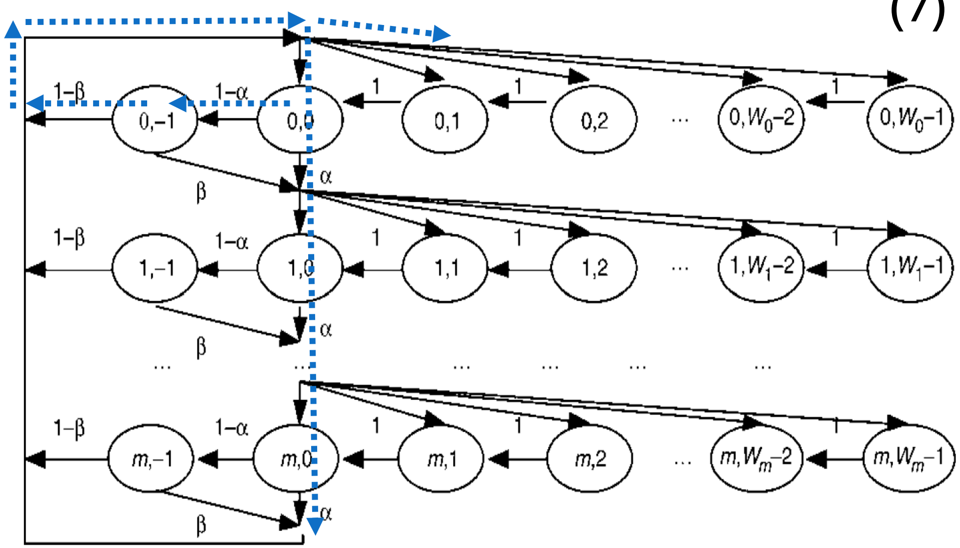
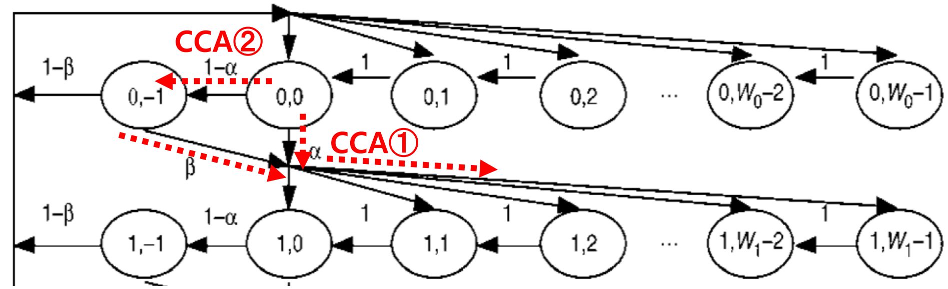
- transition probabilities:

(7)



(8)



CCA 2번 모두 성공후
다시 backoff counter를 통해 (m,0)까지 가는 것을 의미

(7) $b_{i,k} = \dfrac{W_i - k}{W_i} \{(1-\alpha)(1-\beta)\sum_{j=0}^{m} b_{j,0} \quad i = 0$

$(1-\alpha)(1-\beta)(b_{0,0} + b_{1,0} + b_{2,0} + \ldots + b_{m,0})$

$\rightarrow b_{0,0}\ (1-\alpha)(1-\beta) + \ b_{0,0}\ (1-\alpha)(1-\beta) + ..$
$.. + \ b_{m.0}\ (1-\alpha)(1-\beta)$

W_i 번째 stage에서 -k번째 Stationary probability가 선택될 확률

(8) $b_{i,k} = \dfrac{W_i - k}{W_i} b_{i,0} \qquad 0 < i$

CCA 2번 실패후
W_i 번째 stage에서 -k번째 Stationary probability가 선택될 확률

(5) $b_{i,0} = b_{i-1,0}(\alpha + (1-\alpha)\beta)$ 로 정의

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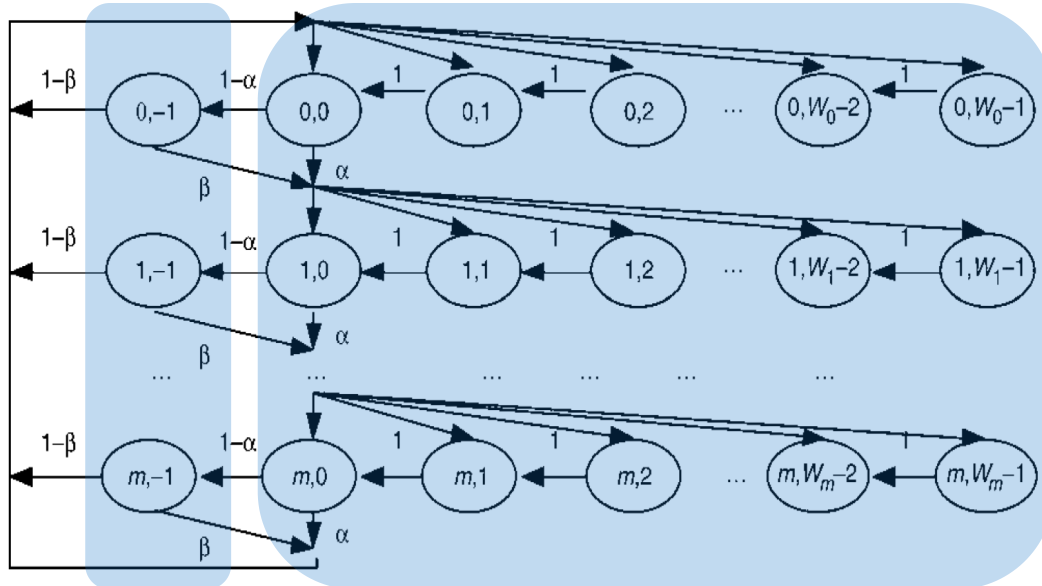
- transition probabilities:

모든 경우

(9)



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- transition probabilities:
  - τ : 임의의 노드가 임의의 시간에서 전송할 확률
  - $(\mathbf{1}-\boldsymbol{\tau})^{\boxed{\boldsymbol{n-1}}}$: 모든 n개의 device가 backoff states에 있을때, 주어진 device가 2번의 CCA 수행후 패킷을 성공적으로 전송하는 확률

    n-1개의 device가 전송하지 않는것
  -

$$= b_{0,0}\ (1-\alpha)(1-\beta)+b_{1,0}(1-\alpha)(1-\beta)+b_{2,0}(1-\alpha)(1-\beta)+\ldots+b_{m,0}(1-\alpha)(1-\beta)$$