IEEE 802.15.4 Study

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IEEE 802.15.4 MAC

- **Superframe structure**

  1) Active period

  2) Inactive period (coordinator → Low-power mode)

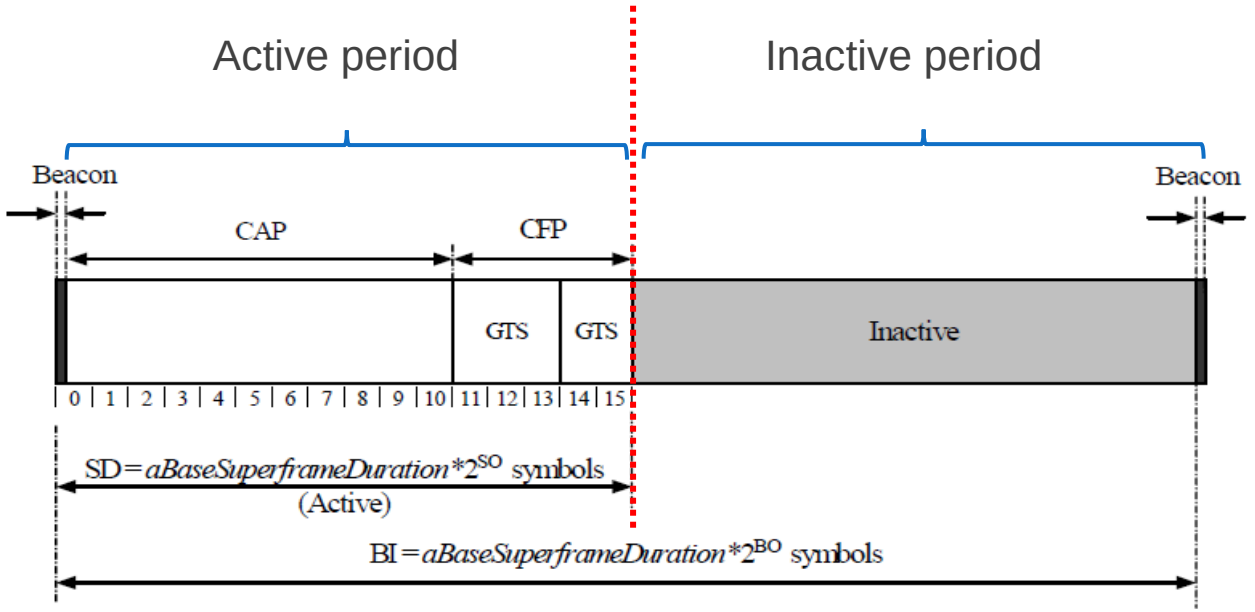

Figure 66—An example of the superframe structure

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- **Superframe structure**

1) Active period

- ✓ Active period는 같은 size의 16개 slot으로 나뉨
- ✓ Active period는 2가지 part로 나뉨
  - Contention Access period (CAP)
  - Contention Free period(CFP)

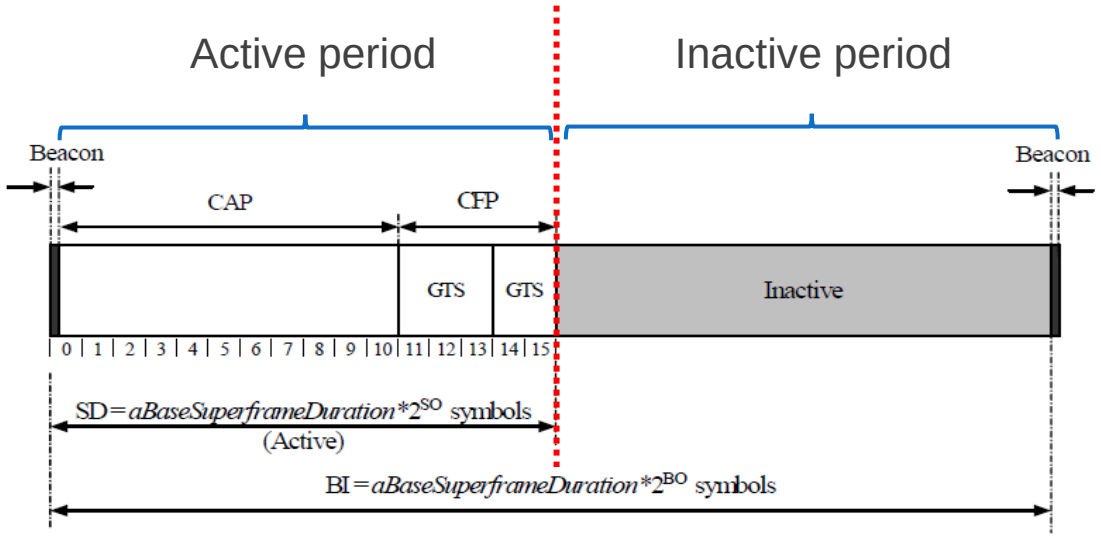

Figure 66—An example of the superframe structure

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- **Active period**
  - CAP(Contention Access Period)
    - ✓ Beacon 다음으로 시작하며 device가 통신을 원하는 구간 (device간의 경쟁구간)
    - ✓ slotted CSMA-CA mechanism으로 동작

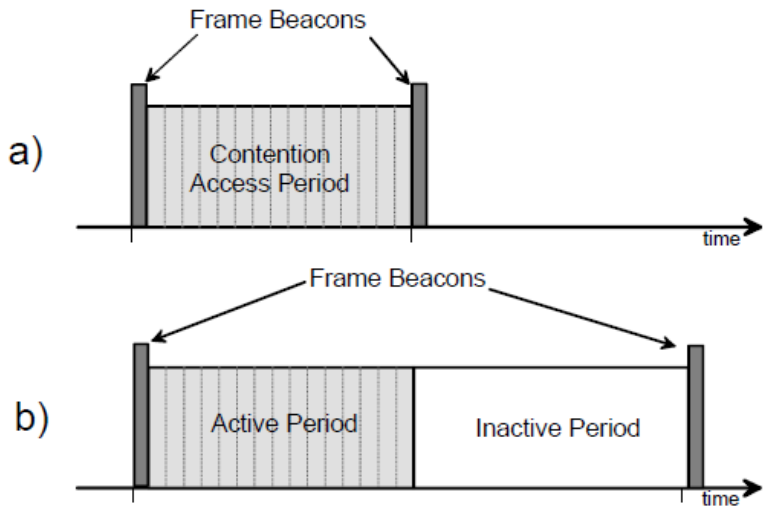

Figure 4—Superframe structure without GTSs

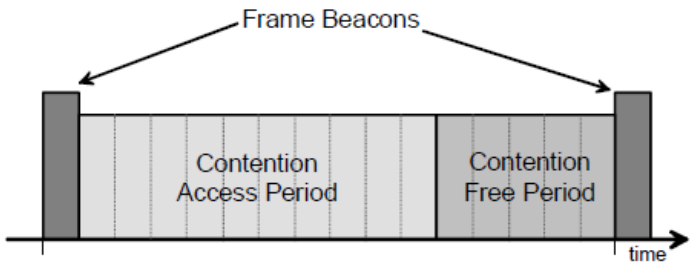

Figure 5—Superframe structure with GTSs

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- **Active period**
  - CFP(Contention Free Period)
    - ✓ Optional 구간 (CAP의 상황에 따라 GTS 할당이 이루어지지 않을수도 있음=Option임)
    - ✓ Station에게 GTS(guranteed time slot)를 할당하여 비경쟁적으로 동작
      - PAN coordinator가 GTS 구간동안 통신할 Devices를 정해줌 (중앙통제)
    - ✓ GTS는 최대 7개까지 할당이 가능하며, 한 개 이상의 slot을 가짐

❖ GTS(Guaranteed time slots)

- PAN coordinator가 최대 7개의 GTS 할당 가능
- 2개 이상의 Slot period를 차지할 수 있음

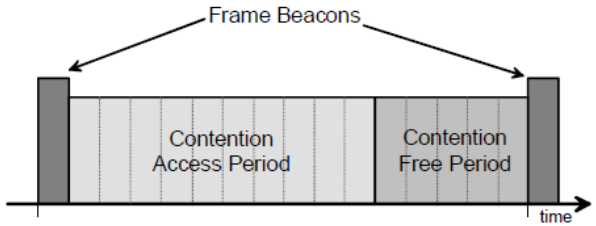

Figure 5—Superframe structure with GTSs

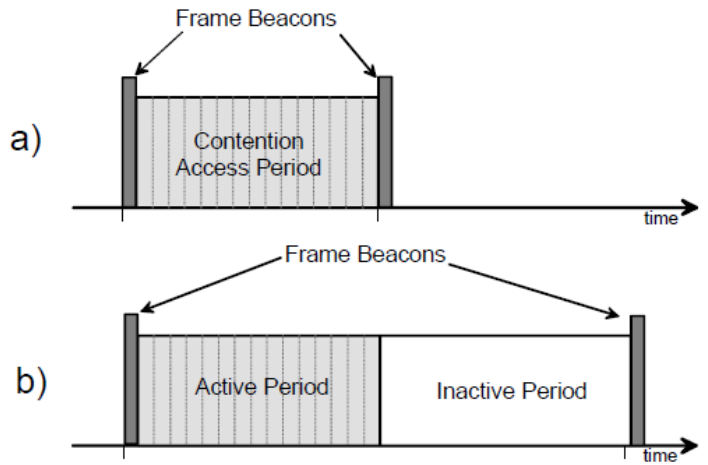

Figure 4—Superframe structure without GTSs

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- **Superframe Structure**
  - **Beacon**
    - ✓ 각 Superframe의 첫 번째 slot에서 전송됨 (Superframe을 시작할 때 사용)
    - ✓ 네트워크 안의 다른 device와 동기화를 위해 사용
    - ✓ PAN coordinator가 전송
    - ✓ 네트워크 정보 포함, 프레임 구조 및 보류중인 노드 메시지 알림

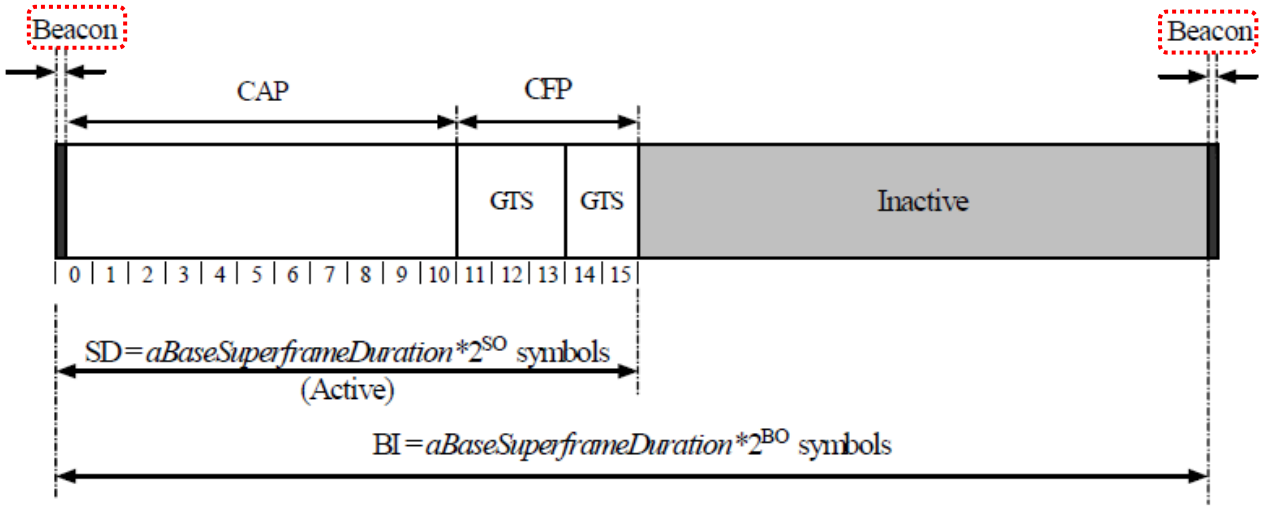

Figure 66—An example of the superframe structure

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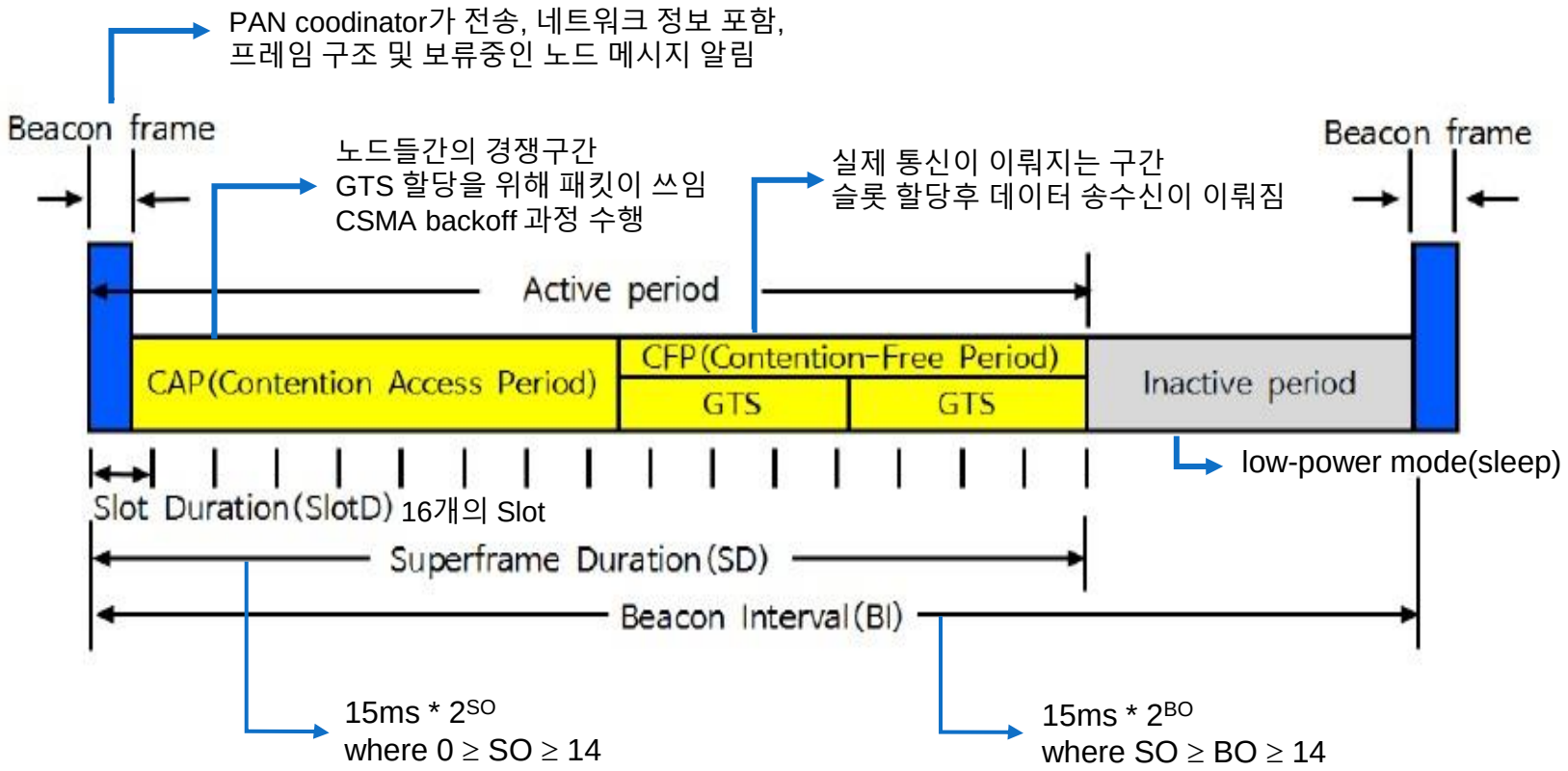
- **Superframe Structure**



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- **Superframe**
  - SD (Superframe Duration) : Superframe의 Active portion의 길이
    - ✓ SD = *aBaseSuperframeDuration**2^{SO} symbols
  - BI (Beacon Interval) : Beacon frame간 간격
    - ✓ BI = *aBaseSuperframeDuration**2^{BO} symbols
  - BO (Beacon Order) : Superframe의 길이 결정
    - ✓ $0 \leq BO \leq 14$

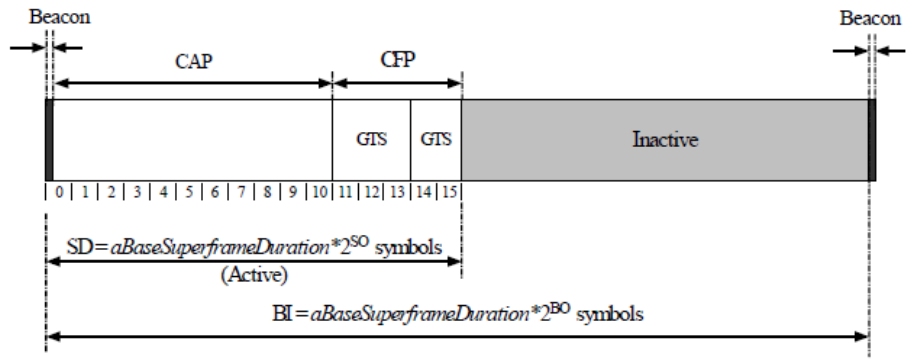

Figure 66—An example of the superframe structure

  - SO (Superframe Order) : Superframe에서 Active 구간의 길이 결정
    - ✓ $0 \leq SO \leq BO \leq 14$

➢ 만약, BO가 15이면 Superframe에서 1개의 unit slot 길이가 SD의 길이와 같아지므로 Beacon을 보내지 않고,
네트워크가 Non-beacon-enabled mode로 동작함

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- **Superframe**
  - Symbol
    - ✓ PHY계층에 따라 달라지는 Bit의 mapping 단위
    - ✓ Ex) PHY 2450MHz - Bit rate/Symbol rate = 4

Table 1—Frequency bands and data rates

PHY (MHz)	Frequency band (MHz)	Spreading parameters		Data parameters		
		Chip rate (kchip/s)	Modulation	Bit rate (kb/s)	Symbol rate (ksymbol/s)	Symbols
868/915	868–868.6	300	BPSK	20	20	Binary
	902–928	600	BPSK	40	40	Binary
868/915 (optional)	868–868.6	400	ASK	250	12.5	20-bit PSSS
	902–928	1600	ASK	250	50	5-bit PSSS
868/915 (optional)	868–868.6	400	O-QPSK	100	25	16-ary Orthogonal
	902–928	1000	O-QPSK	250	62.5	16-ary Orthogonal
2450	2400–2483.5	2000	O-QPSK	250	62.5	16-ary Orthogonal

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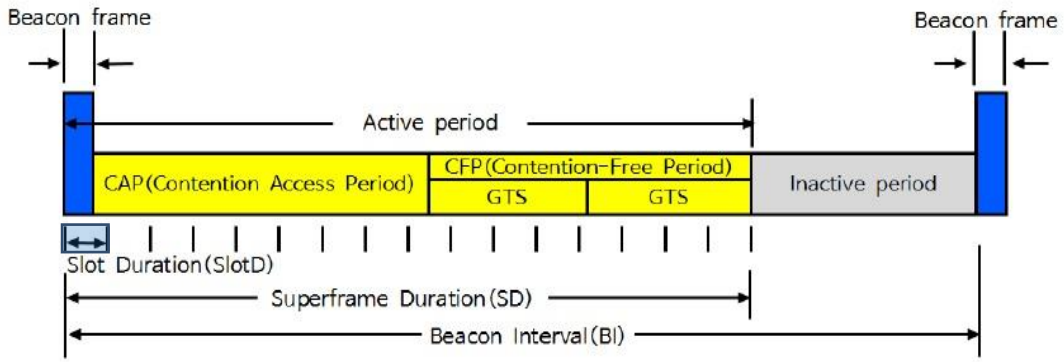
- **Superframe – SlotD 길이 계산**



- 1 symbol = 4bit / bit rate = 250 kbps = 250000 bit
- aBaseSlotDuration(A) = 60 symbols
- aNumSuperframe(B) = 16
- 식 :

$$SlotD = aBaseSlotDuration \times 2^{SO}[symbols] = 60 \times 2^{SO}[symbols] = 0.96 \times 2^{SO}[ms]$$

- **Why?**

SlotD = aBaseSlotDuration * 2^{SO} symbols

= 60 sym * 2^{SO} symbols

= 60 sym * 4 bit / 250 kbps = 0.96 ms

Q. 60* 2^{SO} sym = X ms?

→ 240* 2^{SO} bits = X ms?

→ 240* 2^{SO}/250*10^3 = X ms

→ 250*10^3 : 1 = 240* 2^{SO} : X

→ X = 0.96

→ 0.96 ms

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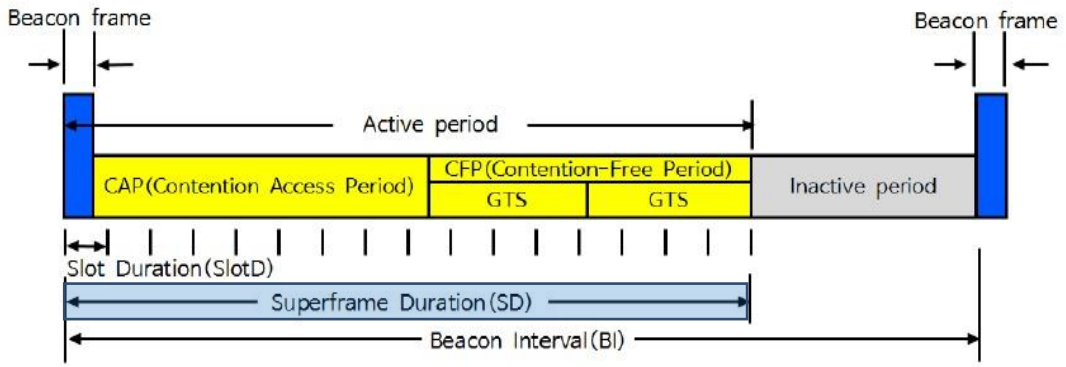
- **Superframe – SD 길이 계산**



- 1 symbol = 4bit / bit rate = 250 kbps = 250000 bit
- aBaseSlotDuration(A) = 60 symbols
- aNumSuperframe(B) = 16
- 식 :

$$SD = aBaseSuperframeDuration \times 2^{SO}[symbols] = 960 \times 2^{SO}[symbols] = 15.36 \times 2^{SO}[ms]$$

- **Why?**

SD = *aBaseSuperframeDuration* * $\mathbf{2^{SO}}$ symbols

= aBaseSuperframeDuration = A*B => 960 symbols = 3840 bits

→ 960 sym * 4 bit / 250 kbps = 15.36 ms

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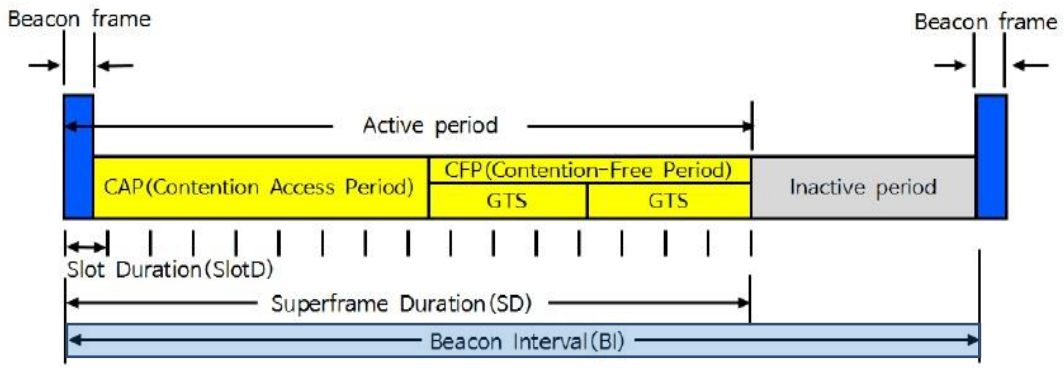
- **Superframe – BI 길이 계산**



- 1 symbol = 4bit / bit rate = 250 kbps = 250000 bit
- aBaseSlotDuration(A) = 60 symbols
- aNumSuperframe(B) = 16
- 식 :

$$BI = aBaseSuperframeDuration \times 2^{SO}[symbols] = 960 \times 2^{SO}[symbols] = 15.36 \times 2^{SO}[ms]$$

- **Why?**

BI = *aBaseSuperframeDuration* * $\mathbf{2^{BO}}$ symbols

= aBaseSuperframeDuration = A*B → 960 symbols = 3840 bits

→ 960 sym * 4 bit / 250 kbps = 15.36 ms

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- **Superframe**
  - Duty Cycle
    - ✓ 전체 구간에서의 Active 구간의 비율을 말함
    - ✓ $2^{-(BO-SO)} = \frac{SD = aBaseSuperframeDuration * 2^{SO} symbols}{BI = aBaseSuperframeDuration * 2^{BO} symbols}$

BO-SO	0	1	2	3	4	5	6	7	8	9	≧10
Duty cycle (%)	100	50	25	12	6.25	3.125	1.56	0.78	0.39	0.195	< 0.1

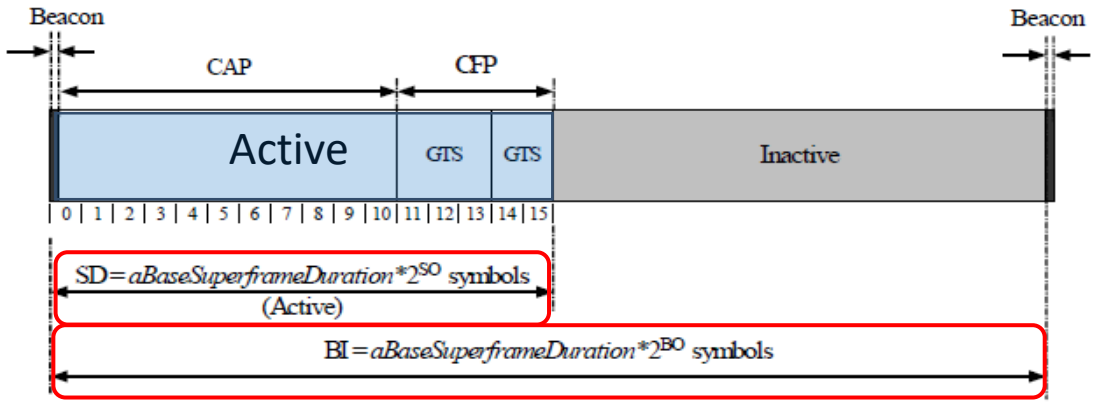

Figure 66—An example of the superframe structure