Wireless Sensor Networks

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Credits: 6

Syllabus: Laboratory Activities

1. PAN Formation
2. Data Transfer (point-to-point)
3. MAC Protocol
4. NET Protocol (small network)

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MAC Protocol

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Outline

1. IEEE 802.15.4 MAC Protocol
2. Aim of the Experiment
3. How to SET MAC parameters
4. Delay evaluation

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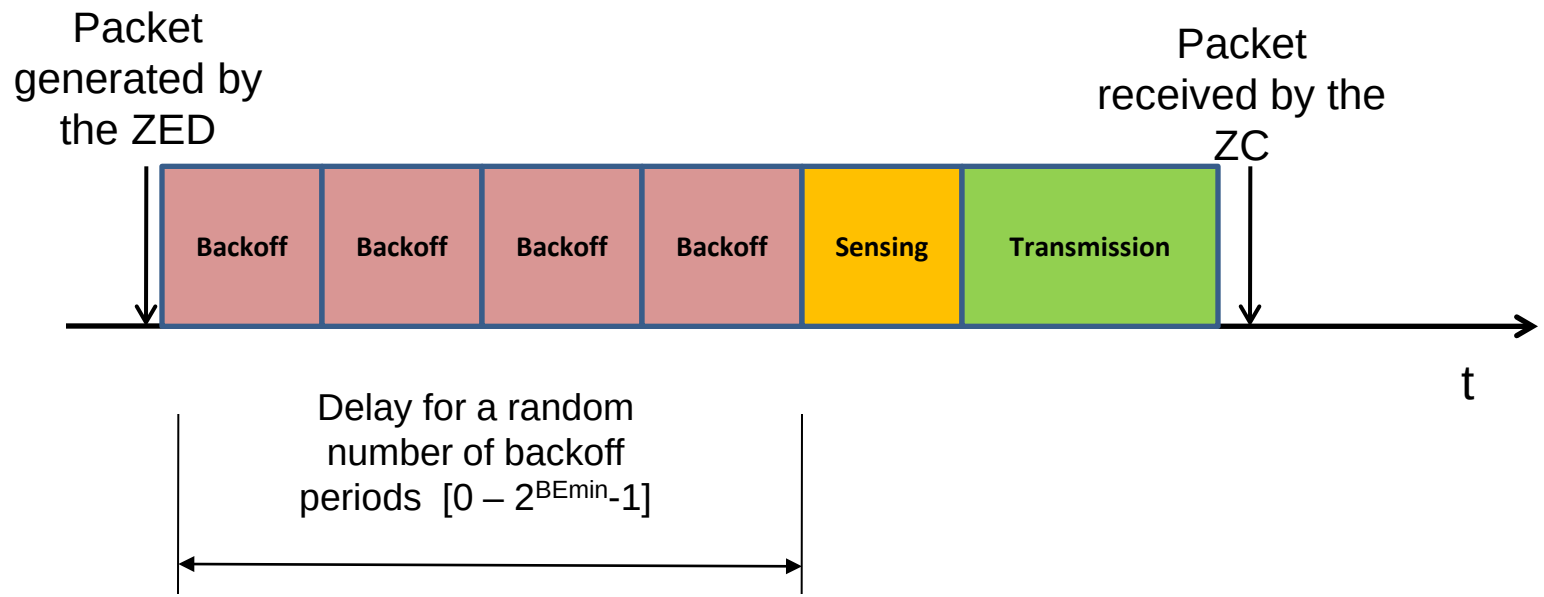
Non Beacon-Enabled Mode: CSMA/CA

ZED transmits a data to the ZC.

Point-to-point → channel is found free at the first time.



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Outline

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2. **Aim of the Experiment**
3. How to SET MAC parameters
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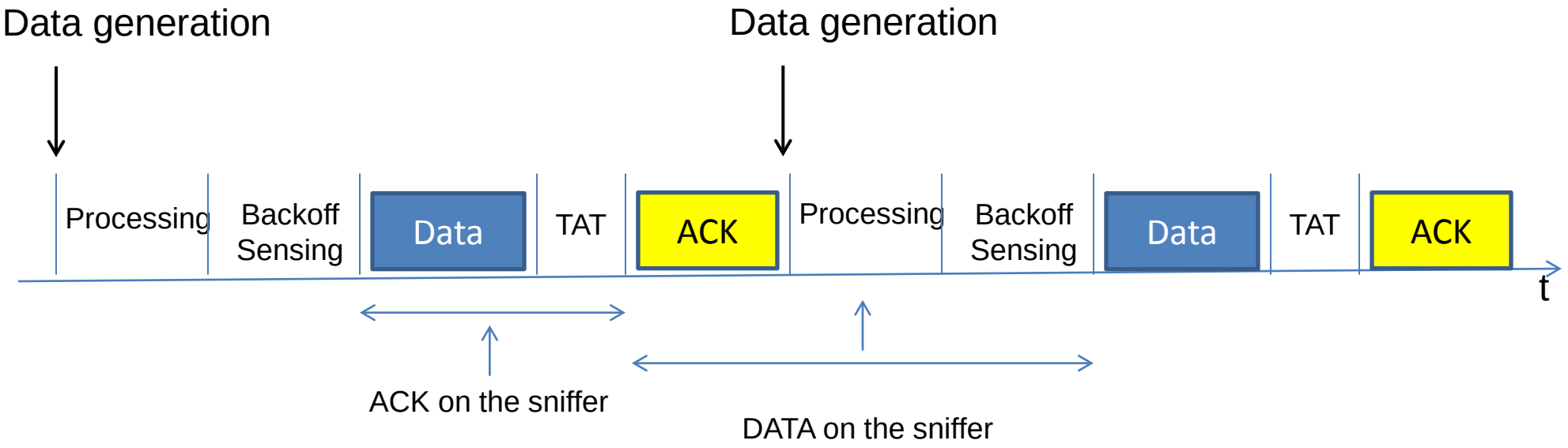
Experiment

- Send many consecutive packets from the ZED to the ZC, by setting different values of BE_{min}
- Observe how the average delay varies by changing BE_{min}



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Set MAC PIB (PAN Information Based) Attributes

The MAC PIB holds all the MAC attributes/variables that are accessible for the application. According to the 802.15.4 Standard, the primitive MLME-SET.request could be used to write a given PIB attribute.

```
MLME-SET.request (
                    PIBAttribute,
                    PIBAttributeValue
                   )

MLME-SET.confirm (
                    status,
                    PIBAttribute
                   )
```

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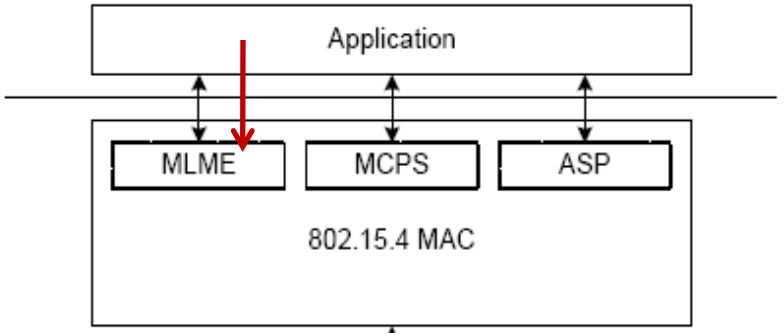
Message Types: NWK-to-MLME direction

Message Identifier (primNwkToMlme_t)	802.15.4 NWK to MLME Primitives
gMlmeAssociateReq_c	MLME-ASSOCIATE.Request
gMlmeAssociateRes_c	MLME-ASSOCIATE.Response
gMlmeDisassociateReq_c	MLME-DISASSOCIATE.Request
gMlmeGetReq_c	MLME-GET.Request
gMlmeGtsReq_c	MLME-GTS.Request
gMlmeOrphanRes_c	MLME-ORPHAN.Response
gMlmeResetReq_c	MLME-RESET.Request
gMlmeRxEnableReq_c	MLME-RX-ENABLE.Request
gMlmeScanReq_c	MLME-SCAN.Request
gMlmeSetReq_c	MLME-SET.Request
gMlmeStartReq_c	MLME-START.Request
gMlmeSyncReq_c	MLME-SYNC.Request
gMlmePollReq_c	MLME-POLL.Request



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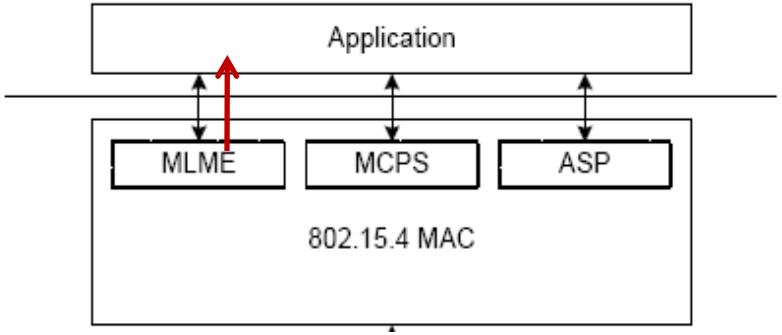
Message Types: MLME-to-NWK direction

Message Identifier (primMlmeToNwk_t)	802.15.4 MLME to NWK Primitives
gNwkAssociateInd_c	MLME-ASSOCIATE.Indication
gNwkAssociateCnf_c	MLME-ASSOCIATE.Confirm
gNwkDisassociateInd_c	MLME-DISASSOCIATE.Indication
gNwkDisassociateCnf_c	MLME-DISASSOCIATE.Confirm
gNwkBeaconNotifyInd_c	MLME-BEACON-NOTIFY.Indication
gNwkGetCnf_c	N/A
gNwkGtsInd_c	MLME-GTS.Indication
gNwkGtsCnf_c	MLME-GTS.Confirm
gNwkOrphanInd_c	MLME-ORPHAN.Indication
gNwkResetCnf_c	MLME-RESET.Confirm
gNwkRxEnableCnf_c	MLME-RX-ENABLE.Confirm
gNwkScanCnf_c	MLME-SCAN.Confirm
gNwkCommStatusInd_c	MLME-COMM-STATUS.Indication
gNwkSetCnf_c	N/A
gNwkStartCnf_c	MLME-START.Confirm
gNwkSyncLossInd_c	MLME-SYNC-LOSS.Indication
gNwkPollCnf_c	MLME-POLL.Confirm
gNwkPollNotifyIndication_c	Freescale proprietary Poll Notify Indication



Freescale 802.15.4 MAC SW
PAN Information Base (PIB) Attributes - SET

```
uint8_t App_SetMacPib_Example(uint8_t attribute, uint8_t *pValue)
{
  mlmeMessage_t mlmeSet;

  /* Create and execute the Set request */
  mlmeSet.msgType = gMlmeSetReq_c;
  mlmeSet.msgData.setReq.pibAttribute = attribute;
  mlmeSet.msgData.setReq.pibAttributeValue = pValue;

  return MSG_Send(NWK_MLME, &mlmeSet);
}
```

Synchronous operation, MSG_Send() call is processed immediately .

The return value of MSG_Send() is gSuccess_c if the set request was processed correctly or gInvalidParameter_c if parameter verification failed.

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Set MAC PIB (PAN Information Based) Attributes

The MAC PIB holds all the MAC attributes/variables that are accessible for the application. According to the 802.15.4 Standard, the primitive MLME-GET.request could be used to read a given PIB attribute.

```
MLME-GET.request (
                    PIBAttribute,
                  )

MLME-GET.confirm (
                  status,
                  PIBAttribute,
                  PIBAttributeValue
                  )
```

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Freescale 802.15.4 MAC SW
PAN Information Base (PIB) Attributes - GET

```
static uint8_t App_GetParam(uint8_t attribute, uint8_t *pValue)
{    mlmeMessage_t mlmeGet;
     mlmeGet.msgType=gMlmeGetReq_c;
     mlmeGet.msgData.getReq.pibAttribute=attribute;
     mlmeGet.msgData.getReq.pibAttributeValue=pValue;
     return MSG_Send (NWK_MLME,&mlmeGet);
}
```

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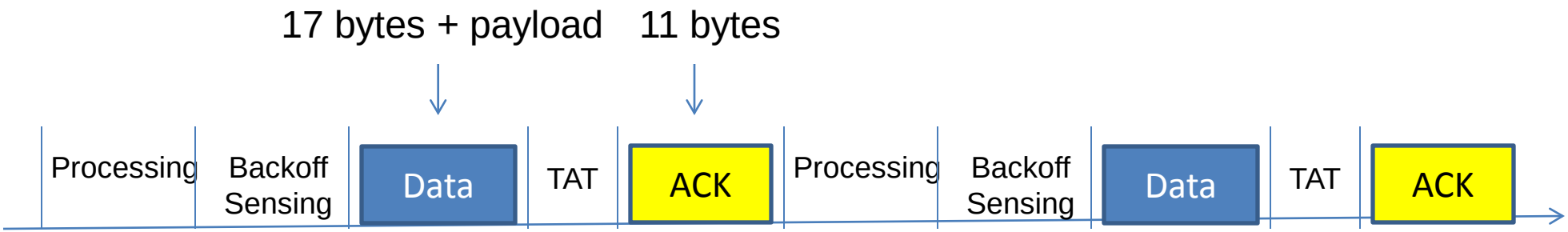
Freescale 802.15.4 MAC SW PAN - Information Base (PIB) Attributes

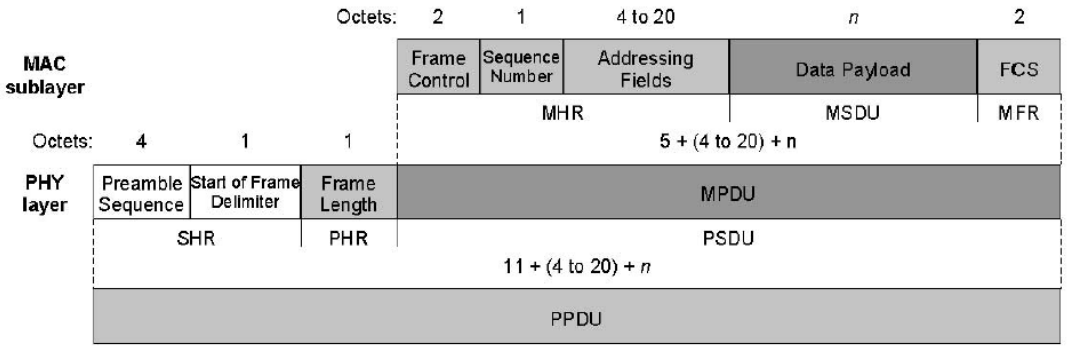
802.15.4 Specific Attributes (see [1] for descriptions)	
0x40	gMPibAckWaitDuration_c
0x41	gMPibAssociationPermit_c
0x42	gMPibAutoRequest_c
0x43	gMPibBattLifeExt_c
0x44	gMPibBattLifeExtPeriods_c
0x45	gMPibBeaconPayload_c
0x46	gMPibBeaconPayloadLength_c
0x47	gMPibBeaconOrder_c
0x48	gMPibBeaconTxTime_c
0x49	gMPibBsn_c
0x4A	gMPibCoordExtendedAddress_c
0x4B	gMPibCoordShortAddress_c
0x4C	gMPibDsn_c
0x4D	gMPibGtsPermit_c
0x4E	gMPibMaxCsmaBackoffs_c
0x4F	gMPibMinBe_c
0x50	gMPibPanId_c
0x51	gMPibPromiscuousMode_c
0x52	gMPibRxOnWhenIdle_c
0x53	gMPibShortAddress_c
0x54	gMPibSuperFrameOrder_c
0x55	gMPibTransactionPersistenceTime_c

Compute the Processing Time - Sniffer



TAT = 12 T_s = 192 μs
Packet Size =
11 + addressing fields + payload

Addressing fields = 6 Bytes



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Timer MC1322

The time pointer points to a 4-byte array where a 30-bit value represents the MACA symbol clock time.
The function does not return any value because the call is always successful.

```
zbClock32_t currentTime=0;

Asp_GetTimeReq(&currentTime);

UartUtil_PrintHex((uint8_t *)&currentTime, sizeof(currentTime),0);
UartUtil_Print("\n\r",gAllowToBlock_d);
```

The timer received on UART is in Simbol Time.

Standard Input / Output

- In the world of microcontrollers, there is no environment that provides standard IO. Unlike ANSI C, there is no *printf()* function that prints formatted strings to the default output and no *scanf()* function that reads formatted strings from standard input.

- In Freescale 802.15.4 MAC Stack:
  - Sending strings to the serial port:

    void UartUtil_Print(uint8_t* pString, uartUtilBlock_t allowToBlock)

    allowToBlock: gNoBlock_d, gAllowToBlock_d

  - Sending hex data to serial port:

    void UartUtil_PrintHex(uint8_t* hex, uint8_t len, uint8_t flags)

    flags: gPrtHexBigEndian_c, gPrtHexNewLine_c , gPrtHexCommas_c, PrtHexSpaces_c

Printing data on UART

```
UartUtil_Tx(pMsgIn->msgData.dataInd.pMsdu, pMsgIn->msgData.dataInd.msduLength);
UartUtil_Print(" ",gAllowToBlock_d);

UartUtil_PrintHex(&pMsgIn->msgData.dataInd.mpduLinkQuality,1, gPrtHexBigEndian_c |
gPrtHexNewLine_c);

UartUtil_Print("\n\r",gAllowToBlock_d);
```

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