Nano Power Draw in Duty-Cycled Wireless Sensor Networks

- ✓ Sensor networks operate in duty-cycling fashion for energy saving purposes, since overhearing and idle listening is a major source of energy wastage.
- ✓ Despite the fact that more than three orders of magnitude separate current consumption in sleep and active states, both states account for systems' power budget expenditure, considering that typical sensor applications operate at quite low duty-cycles ranging from 0.01 % to 1 %.
- ✓ We present a novel mechanism exploiting an off-chip timer circuit along with a load switch to control the go-to-sleep and wake-up functions of any IoT node.

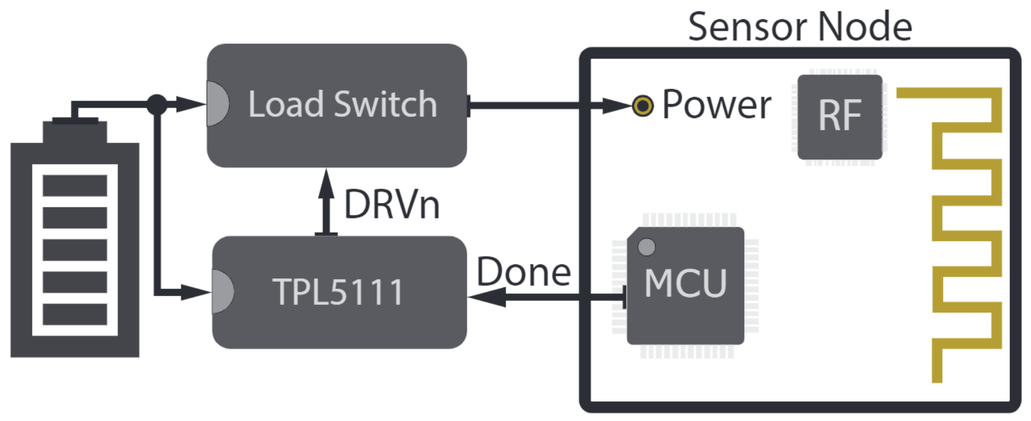
Iot Devices	Sleep Current	Principle
TelosB	8.8 µA	Integrated WDT timet
MicaZ	15 µA	Integrated RTC
Opal	1 ms	Integrated RTC
Waspmote	110.4 us	Integrated RTC
eZ430-RF2500	690 nA	200 nA
Current implementation	33 nA	off-chip timer

Indicative Devices

- ✓ The proposed principle comes at the cost of additional time required for the sensor to enter an active state since cold-start booting takes comparatively longer than waking-up from a standby state.
- ✓ *MCUs* featuring fast wake-up times such as the *MSP430 family* are less likely to affect the overall active energy.

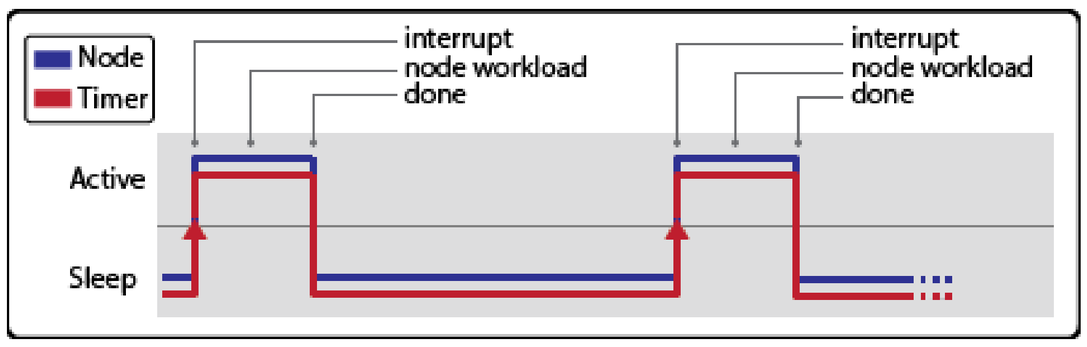
MCU	Wake-up	Sleep Current
MSP430FR5969 Standby (LPM3.5)	250 us	200 nA
MSP430FR5969 Deep-Sleep (LPM4.5)	1 ms	20 nA
MSP430FR5969 Cold Start	1 ms	-
ATmega328P Standby (WDT)	110.4 us	4.8 uA
ATmega328P Deep-Sleep	110.4 us	200 nA
ATmega328P Cold Start	61.4 ms	-
ATmega1284P Standby (WDT)	5.71 ms	4.5 uA
ATmega1284P Deep-Sleep	5.71 ms	850 nA
ATmega1284P Cold Start	67.5 ms	-

Indicative MCUs & Characteristics

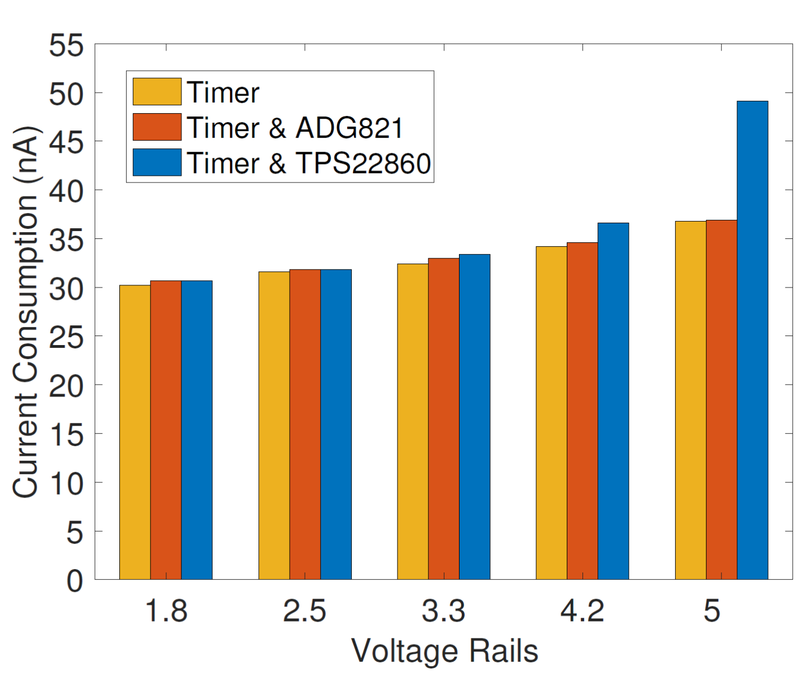


Architecture diagram of the proposed principle

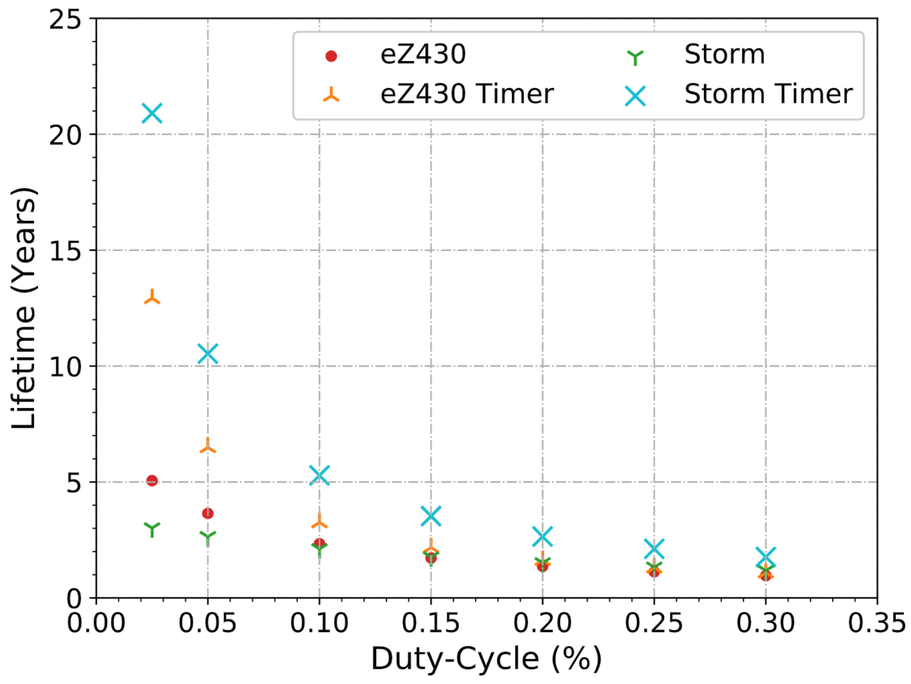
- ✓ Our prototype uses a TPL5111 timer circuit by Texas Instruments and the ADG821 load switch that can drive loads up to 200 mA.



Sensor node's activity with TPL5111 timer



Power consumption under various voltage rails



Life expectancy of indicative IoT devices when our principle is applied and when not

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